I. C. 6872

DECEMBER 1935

DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

METHODS OF DEVELOPMENT AND PILLAR EXTRACTION IN MINING THE PITTSBURGH COAL BED IN PENNSYLVANIA, WEST VIRGINIA, AND OHIO

RECEIVED
JAN 22 1936
O. S. U. LIBRARY

BY

J. W. PAUL AND L. N. PLEIN

AFTER THIS REPORT HAS SERVED YOUR PURPOSE AND IF YOU HAVE NO FURTHER NEED FOR IT, PLEASE RETURN IT TO THE BUREAU OF MINES, USING THE OFFICIAL MAILING LABEL ON THE INSIDE OF THE BACK COVER.

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

Original from
THE OHIO STATE UNIVERSITY

I.C.6872,
December 1935

INFORMATION CIRCULAR

DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

METHODS OF DEVELOPMENT AND PILLAR EXTRACTION IN MINING THE PITTSBURGH COAL BED IN PENNSYLVANIA, WEST VIRGINIA, AND OHIO[1]

By J. W. Paul[2] and L. N. Plein[3]

INTRODUCTION

The United States Bureau of Mines has made a study of roof control in 68 mines operating in the Pittsburgh coal bed in Pennsylvania, West Virginia, and Ohio. In making these studies, much information was also obtained on various exact methods of development and pillar extraction as practiced by this large group of mines. It is proposed in this paper to describe these methods, by which this group of mines in 1931, a year of reduced industrial activity, produced 28,123,000 tons of bituminous coal - 7.4 percent of the national production for the same year and an amount equal to the combined production of the coal mined in the States of Alabama, Colorado, New Mexico, Utah, and Wyoming. The results of these studies, insofar as they pertain to the prevention of injuries from falls of roof, have been published by the Bureau of Mines. In this paper only a few mines typical of each system will be described; however, should the reader be interested in other details with respect to these mines, he may refer to the following publications:

T.P. 522, 1932, 43 pp. Falls of roof and coal in mines operating in the Pittsburgh coal bed in Marion and Monongalia Counties, W. Va., by J. W. Paul and J. N. Geyer.- A study of nine mines in these two counties of northern West Virginia.

T.P. 534, 1932, 34 pp. Falls of roof and coal in mines operating in the Pittsburgh coal bed, Panhandle district, W. Va., by J. W. Paul and J. N. Geyer.- A study of six mines in Brooke, Ohio and Marshall Counties.

T.P. 541, 1932, 97 pp. A study of mine roof of the Pittsburgh coal bed in the Pittsburgh mining district, by J. W. Paul and L. N. Plein.- A study of fifteen mines in Allegheny and Washington Counties, Pennsylvania.

T.P. 547, 1933, 23 pp. Falls of roof in mines operating in the Pittsburgh coal bed, West Virginia, by J. W. Paul and J. N. Geyer.- A résumé of twenty mines studied in the Fairmont and Panhandle Districts.

T.P. 550, 1933, 31 pp. A study of roof in Pennsylvania mines contiguous to the Monongahela River, by J. W. Paul and J. G. Calverley.- A study of seven mines principally in Greene and Washington Counties, Pennsylvania.

T.P. 563, 1935, 34 pp. A study of mine roof in the Coking District of Western Pennsylvania, by J. W. Paul and L. N. Plein.- A study of twelve mines principally in Fayette County.

R.I. 3070, 1931, 32 pp. A study of falls of roof and coal in mines in the Number 8 Field of Eastern Ohio, by J. W. Paul and L. N. Plein.- A study of seven mines in Belmont, Harrison and Jefferson Counties.

---

1 The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U.S. Bureau of Mines Information Circular 6872."

2 Former senior mining engineer, U.S. Bureau of Mines, Pittsburgh Experiment Station, Pittsburgh, Pa.

3 Associate engineer economist, U.S. Bureau of Mines.

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

R.I. 3110, 1931, 30 pp. A study of falls of roof and coal in mines of Harrison County, W. Va., by J. W. Paul and J. N. Geyer.- A study of five mines in this county.

R.I. 3113, 1931, 77 pp. Roof support in coal mines in the Irwin, Greensburg and Latrobe Basins, Westmoreland County, Pa., by J. W. Paul, H. Tomlinson, and S. J. Craighead.- A study of twelve mines.

I.C. 6200, 1929, 21 pp. Method and cost of mining the Pittsburgh or No. 8 Coal Bed in a 100 percent mechanized mine in Eastern Ohio, by W. F. Hazen and E. J. Christy.- A study of methods and costs of a mine using mechanical loading.

I.C. 6208, 1929, 21 pp. Method and cost of mining the Pittsburgh or No. 8 Coal Bed in four Eastern Ohio mines, by J. W. Paul and H. Tomlinson.- A study of four mines in Belmont and Harrison Counties.

The Pittsburgh coal was one of the first beds of bituminous coal to be extensively mined in this country, and therefore the literature on its geology, structure, composition, and method of extraction is rather lengthy; it is described in publications of Government bureaus, transactions of technical societies, and in the technical press. This paper is not intended to be a résumé of all that has been published, nor a history of the changes in methods of mining.

Most of the mines used as the basis of discussion in this report were carefully studied during the calendar years 1928 to 1932, inclusive. The manuscript was completed early in 1933 but lack of printing funds has delayed its publication. Some of the mines described have since modified their methods but it is believed that the paper still gives a good picture of mining practice in the Pittsburgh coal bed.

THE PITTSBURGH COAL BED

Because of its quality, persistence, thickness, areal extent, and uses as a steam, coking, and gas-making coal, the Pittsburgh bed may well be classed as one of the world's greatest coal deposits. Because of its proximity to industrial markets and because it is served by excellent systems of rail and river transportation, it probably is being exhausted more rapidly than any other bed of coal.

The bed occurs and is mined in four States: Pennsylvania, West Virginia, Ohio, and Maryland. Its general extent is shown in figure 1, which, however, does not include the Georges Creek field of Maryland. In 1931 the production from the Pittsburgh bed of coal was 80,000,000 tons of coal or 20.8 percent of the national production of bituminous coal for that year. In the same year the combined production of Illinois and Kentucky, our third and fourth largest coal-producing States, was 85,000,000 tons. The areal extent of the Pittsburgh coal bed has been estimated at 5,729 square miles with minable reserves of approximately 22 billion tons.[4]

Much has been published on the geology of the Pittsburgh coal bed, the rocks with which it is associated, the topography of the region, its chemical composition, and other features, and for detailed information with respect to these matters the reader is referred to publications of the United States Geological Survey, United States Bureau of Mines, the geological surveys of Pennsylvania, West Virginia, Ohio, and Maryland, Transactions of the American Institute of Mining and Metallurgical Engineers, other technical and scientific institutes, and the technical press.

4 White, I. C., Ashley, G. H., and Bownocker, J. A., The Pittsburgh Coal Bed: Trans. Am. Inst. Min. and Met. Eng., vol. 74, 1926, pp. 481-503; discussion, 503-506.

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

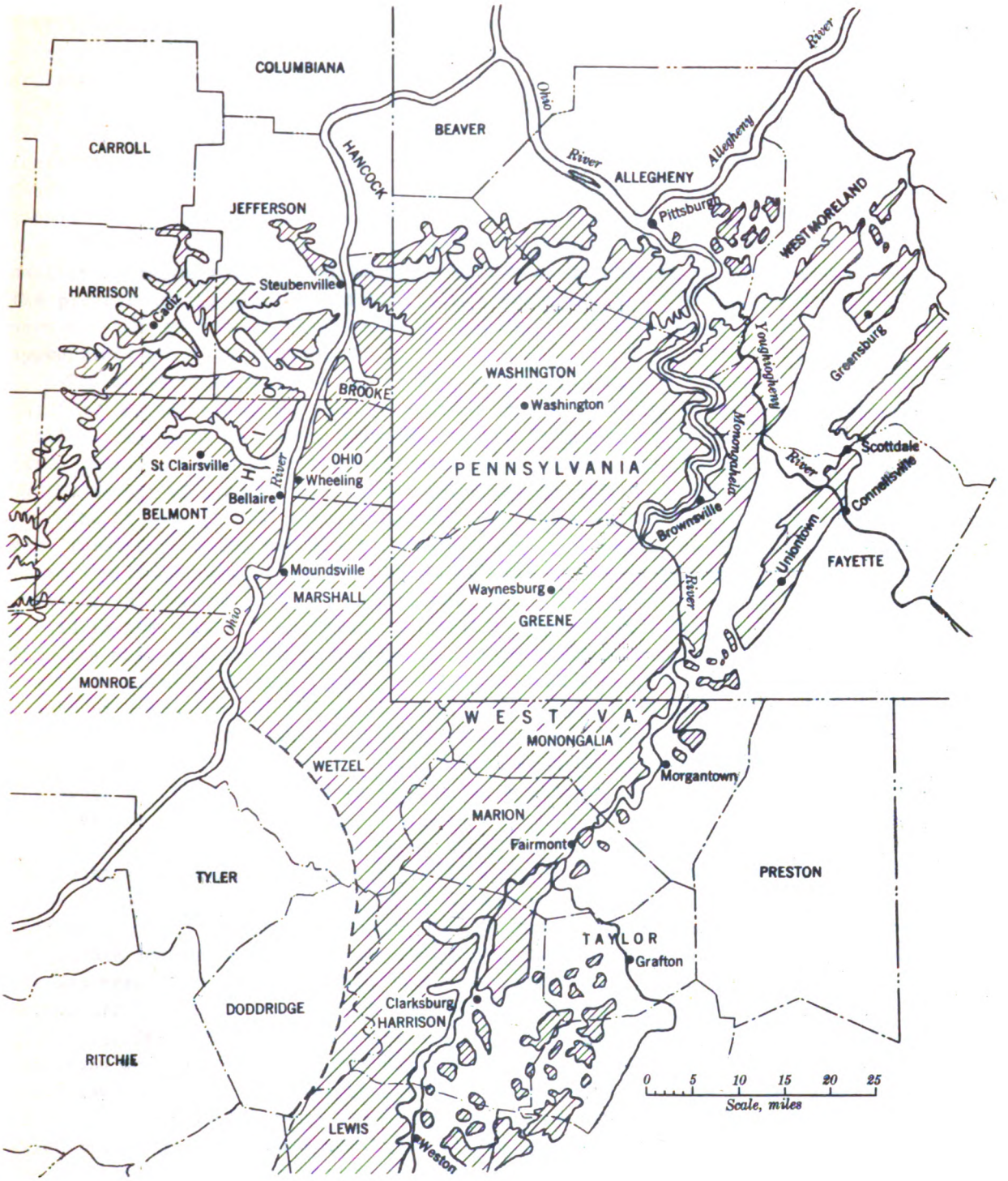

Figure 1.- Map of Pittsburgh coal field in Pennsylvania, West Virginia, and Ohio.

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Briefly, the Pittsburgh coal bed lies in a very broad structural basin or trough whose major axis has a northeast and southwest trend through the city of Pittsburgh. West of this line the coal bed has a general dip to the southeast, and east of this line the bed has a general dip to the northwest but is thrown into a succession of minor folds which in general are parallel to the major axis of the basin. Structure determines the coal-bed dip, which of course, has an important bearing on such mining problems as haulage and drainage. The dip at the mines studied varied from 0 to 6 percent in a few mines, the average being 1.3 percent: Therefore, as compared to coal beds in the anthracite region of Pennsylvania or in the Rocky Mountain States, the Pittsburgh coal bed may be considered practically flat. In the discussion of the various types of mining, unless otherwise stated, it should be understood that the coal bed is practically flat and that the dip has no effect upon methods of development, haulage, or drainage, although in some cases minor changes in details may result according to the prevailing dip of the coal bed. In a few cases where the dip reaches a maximum of 6 percent, the method of development is altered. These changes will be discussed at the appropriate point in this paper.

Topographically the area varies from gently rolling country, as in eastern Ohio and many parts of Pennsylvania and West Virginia, to rather hilly country with V-shaped valleys, particularly along the Ohio, Monongahela, and Youghiogheny Rivers and their major tributaries. In the present mining districts the presence or absence of the coal bed is determined by the amount of erosion which has taken place in recent geologic time.

The Pittsburgh coal bed has certain physical characteristics which might be termed its key "fossils." These are the two characteristic binders (sometimes only one and sometimes three), which usually occur in the lower half of the bed, and its immediate roof, which normally is composed of a draw slate and a roof coal. In thickness the bed varies from 51 to 114 inches. In the Panhandle districts of Pennsylvania and West Virginia and in eastern Ohio the coal is about 60 inches thick. Going eastward into Allegheny and Washington Counties it is about 66 inches thick. In Westmoreland County it is 84 inches thick, in Fayette County 96 inches thick, and in northern West Virginia 108 to 120 inches thick. The well-defined face and butt cleats of the bed are an important factor in the method of development, which in most of the mines studied is planned so that rooms are advancing on the face cleats. The amount of cover varies from outcrop to a maximum of 900 feet with an average cover of 300 feet for the mines studied.

No attempt is made in this paper to give a detailed discussion of the stratigraphy of the rocks overlying the Pittsburgh bed of coal, as that subject is fully covered in publications of the United States Geological Survey and reports of the geological surveys of the various States. The amount of cover at the various mines indicates that in ascending order the strata of the Monongahela and Dunkard formations compose the overlying beds of rocks. The Monongahela formation extends from the base of the Pittsburgh coal bed to the top of the Waynesburg coal bed. The formation varies from 300 to 400 feet in Pennsylvania and northern West Virginia to 200 feet on its western outcrop in Ohio. In ascending order it contains the following coal beds: Pittsburgh, Redstone, Sewickley, Uniontown, and Waynesburg. The Pittsburgh bed is minable wherever it exists, but the other beds are variable and are only mined locally. The most important lithologic member of this formation is the Benwood limestone, which occurs in the middle of the formation and varies from 70 to 120 feet in thickness. Shales, sandy shales, and sandstones compose the remainder of the formation. The only other important detail of stratigraphy is the gradual change in the character of the rocks forming the immediate roof over the Pittsburgh coal bed. As the formation is followed westward, there is a change from sandstones and sandy shales, to shales and calcareous shales, to calcareous shales and limestone.

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Where the cover exceeds 300 to 400 feet the Dunkard formation forms part of the overlying strata in addition to the Monongahela formation. The Dunkard formation is variable in thickness and is composed of sandstones, shales, and limestones. It is divided into an upper and lower member termed the "Greene" and "Washington" groups, respectively.

In discussing each group of mines, further details will be given as to cover, thickness of coal bed, and character of immediate roof.

METHODS OF DEVELOPMENT

The method of development of any coal bed is determined, to some extent, by dip, cover, direction of cleats, if present, location of transportation facilities with respect to area to be mined, and character of immediate roof; however, the method of pillar extraction to be used is one of the most important factors in making decisions upon the finer points of development. The following is a classification of the methods used by the 68 mines studied. This classification is based primarily on the method of pillar extraction, and, secondarily, for simplification in presentation, on a geographic basis. All of the mines studied can be classified in one of the following groups:

Class A.- All coal is mined on advance; this means that room pillars are not extracted. This is common practice in the No. 8 field of Ohio and the Panhandle district of West Virginia. Type A.

Class B.- Part of coal is mined on advance and pillars mined on retreat. This is common practice in Pennsylvania and the Fairmont district of West Virginia. This classification can be subdivided further.

I. Full advance with room pillars mined as butt entry develops. Used by mines in the Panhandle district of Pennsylvania. Type B.

II. Full retreat with short rib lines. Used by a few mines in Washington County, Pa. Type C.

III. Half advance and half retreat. This practice is common in that part of Allegheny and Washington Counties south of Pittsburgh, Pa. Type D.

IV. Full retreat with long fracture lines. This is the predominant practice in the Westmoreland-Ligonier field and the areas adjacent to the Monongahela River in Fayette, Greene, and Washington Counties in Pennsylvania, and the Fairmont district of West Virginia. Type E.

1.- Pocket-and-stump method of pillar extraction:

(a) Rooms developed on centers of 50 feet or less with correspondingly narrow pillars. Used by certain mines in the vicinity of Greensburg, Pa., with moderately light cover. Group A of type E.

(b) Rooms developed on centers of more than 50 feet with correspondingly thicker room pillars. Used by certain mines in the vicinity of Greensburg, Pa., with moderately heavy cover. Group B of type E.

(c) Rooms developed on block system with rooms on centers of 60 feet or more. Used by mines in Greene, Fayette, and Washington Counties. Group C of type E.

(d) Rooms developed on block system in Fairmont district of West Virginia. Group D of type E.

2.- Open-end system of pillar extraction:

(e) Rooms developed on block system, but pillars are extracted by an open-end method. This is a fairly recent development in the coke district of Pennsylvania. Group E of type E.

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

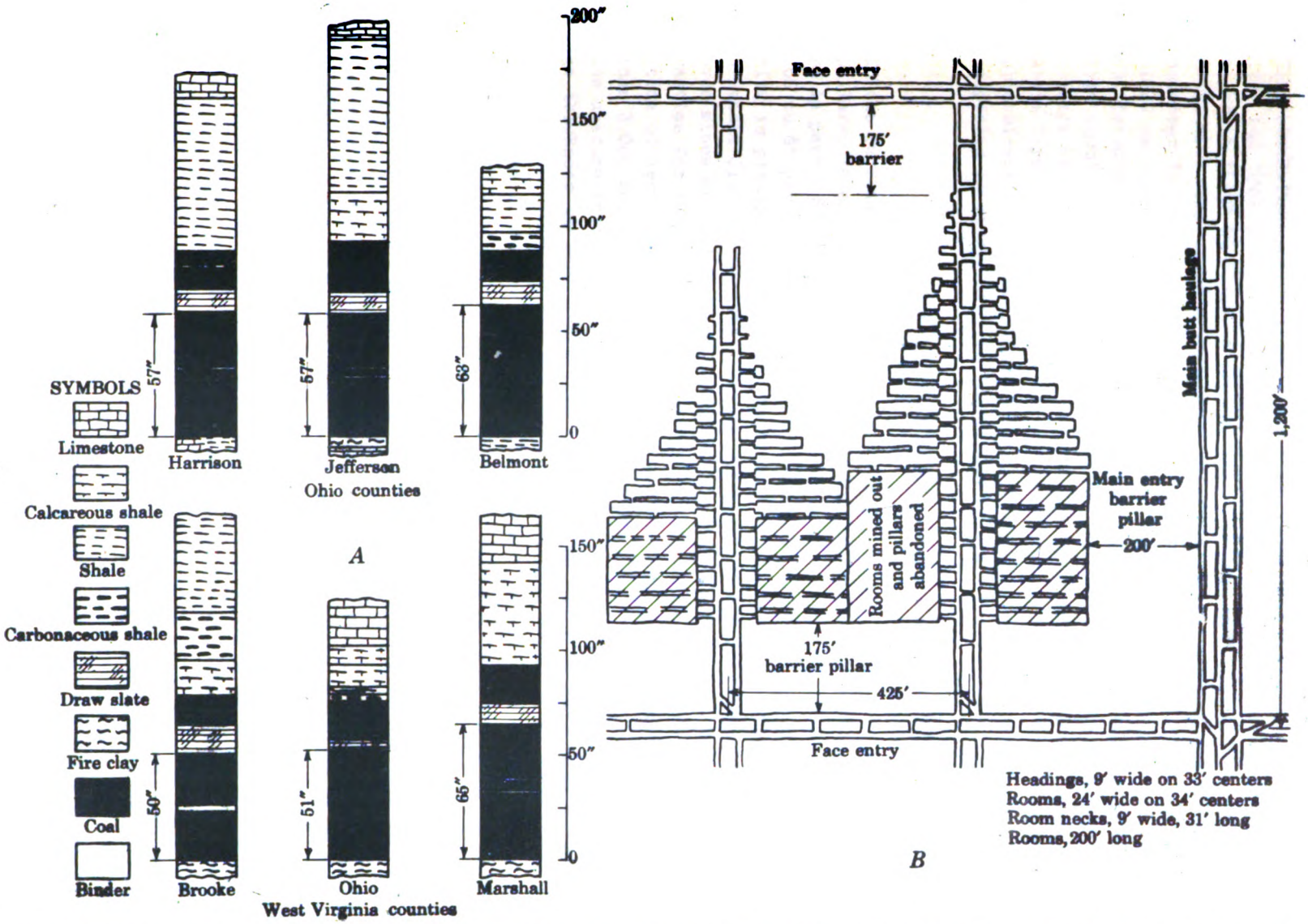

Figure 2.- Coal and roof sections and method of development in the No. 8 field of eastern Ohio and the Panhandle district of West Virginia, type A mines: A, Representative sections of the coal bed and immediate roof in six mines in the counties composing the No. 8 field of eastern Ohio and the Panhandle district of West Virginia; B, method of development of a mine in Belmont County typical of mines in the No. 8 field and the Panhandle district.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

This classification shows five types of mining methods based on character of pillar extraction, and type E has been subdivided into five groups. Rather than describe all the variations in these 68 mines, a typical mine for each method will be described and comparisons given with other mines of the same type. The mines described are representative of what is considered to be the best practice in each system. Each of the types could be further subdivided on the basis of minor differences, but as this would not clarify the discussion these differences will be noted in describing each system. The number of mines studied for each type should not be taken as an indication of the order of predominance of each type. More tonnage is produced by type E han all the other types combined. Type A is predominant in eastern Ohio and the Panhandle of West Virginia. Group E of type E is becoming more and more predominant in Fayette County and probably will be used extensively in extracting the large deposits of virgin coal in Greene County, Pa.

Type A.- Full Advance - Room Pillars Not Mined

In the full-advance method the coal is mined on the advance by entry headings and rooms; room pillars, room stumps, and entry-chain pillars are abandoned but barrier pillars are recovered in part. Such a method does not result in a high percentage of extraction, the range being 55 to 65 percent, which means that 35 to 45 percent of the coal is lost. This method of mining is practiced in Belmont, Harrison, and Jefferson Counties in eastern Ohio and in the Panhandle district of West Virginia which includes Brooke, Marshall, and Ohio Counties. The seven mines studied in Ohio and the six in West Virginia are representative of the average practice for this type of development. At the time these mines were studied four had a production of less than 1,000 tons, 3 more than 1,000 tons, 3 more than 2,000 tons, and 3 more than 3,000 but less than 4,000 tons per day.

The average thickness of the Pittsburgh coal bed in these 13 mines is 59 inches. The average thickness at each individual mine does not vary by more than 6 inches from that average except at two mines where the average thickness was 51 to 52 inches; therefore, insofar as thickness of coal is concerned, all 13 mines have about the same condition. Likewise the immediate roof at all mines is similar, consisting, in ascending order, of an average thickness of 11 inches of draw slate which is taken down as the face of the working place advances, 13 inches of roof coal, 7-1/2 feet of calcareous shales and a main roof of limestone. While these are the essential components of the roof, considerable variation is found in the various mines. The draw slate averages about 12 inches in thickness for this district, but there are variations in individual mines from as little as 3 inches to as much as 52 inches of draw slate and these variations may be found on opposite ribs of a heading. The roof coal also varies in thickness but not as greatly as in the case of the draw slate. Figure 2,A, gives some typical coal and roof sections for these mines.

The depth of cover ranges from nothing at outcrop to a maximum of 800 feet. Some of the development features are based on the amount of cover and these mines have been grouped on that basis.

Figure 2,B, represents the plan of development of a mine in Belmont County and is representative of all mines of this type except for certain variations which will be described later. Panels are developed by driving main butt entries and face entries. Butt entries are driven and, as they advance, rooms are driven 24 feet wide on 33- or 34-foot centers. The rooms are driven their full length and then abandoned, no attempt being made to recover the pillar coal or to salvage the timber. Track is laid up the center of the room, and after the room is completed the rails are pulled and the place is then abandoned. Room stumps and butt-entry chain pillars are abandoned when the butt entry is completed. Usually some of the coal in barrier pillars is recovered by driving rooms off face entries in the same manner

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

that they are driven off butt entries. Naturally, such a method of mining results in a low recovery and it also adds to the cost of haulage, drainage, ventilation, and supervision because to produce a given tonnage the work is of necessity scattered over a large acreage. Less timber should be needed and there should be fewer accidents because pillars are not mined, but this is not necessarily true.

Figure 2,B, gives the plan of development and table 1 gives the details of development and operating results for a representative mine in Ohio and one in West Virginia, and the average for seven mines with average cover of less than 200 feet and for 6 mines with average cover of more than 200 feet. As table 1 shows, the methods of development vary only slightly in each of the 13 mines. The width of pillars is generally increased in those mines having a greater depth of cover. The average length of rooms is about 200 feet. Longer rooms would not be practical because only 8- to 10-foot room pillars are left and a roof squeeze might develop if the rooms had to be maintained for a length of 300 to 400 feet. As the rooms reach the limit of their length, the pillar is gradually reduced until it may be only 2 or 3 feet thick. Rarely are rooms driven on sights, with the result that the thickness of room pillars is liable to be irregular.

Various methods are used to prevent roof squeezes. Barrier pillars, chain pillars and room stumps are used at all mines. In table 1 it should be noted that for light cover the average width of protection on a butt entry, consisting of two room stumps and the butt entry with its two headings and one chain pillar, is 75 feet, and for heavy cover is 88 feet; for light cover 75 percent of this is coal in pillars, and for heavy cover 80 percent is coal in pillars.

In addition to the protection afforded by chain pillars and room stumps other methods of protecting against general squeezes are used. At one mine with an average cover of 500 feet, two rooms off each butt heading near the center of the panel are not mined until all the other rooms on the butt entry panel are completed. This leaves a block of coal 78 feet wide by 200 feet long on each side of the butt entry. Another mine with an average cover of 100 feet drives rooms in groups of five, leaving a solid block of coal 50 feet wide and 200 feet long between each block of five rooms. No attempt is made to recover this coal. A common method used in Ohio for mines with light cover is to leave room blocks as illustrated in figure 3,A. The coal in this room block is seldom recovered. At one mine with an average cover of 500 feet no room blocks were used, but the room headings were driven on 40-foot centers with room necks 17 feet long and squeezes were prevented. Although the usual practice is to drive rooms off both headings as the headings advance, the practice may be varied if the roof is bad; in such places the rooms are completed off one butt heading before those on the parallel butt heading are started. Another variation is to develop the butt entry complete and then drive half of the rooms (on the inby end) before starting the other half of the rooms (on the outby end). At one mine in West Virginia the face entries are turned on 1,200-foot intervals, but the room entries are stopped just short of 600 feet to isolate each butt panel for control of ventilation and for better roof control. On these short 600-foot butt entries all rooms are started at approximately the same time. Another beneficial practice is to drive rooms 200 to 225 feet long off the inby butt heading and those off the outby butt heading only 125 to 145 feet because these are approaching areas which have been mined out, which means about 60 percent recovered, and the roof is riding on the coal that is left in pillars; therefore, it is best that these rooms be short and mined as quickly as possible. The 200 to 225 foot rooms are advancing in solid coal. However, in this case it should be understood that the roof cannot be correctly described as being under control, but is only temporarily supported by pillars. As shown later with the system of mining known as full retreat with long fracture lines, the rooms and pillar pockets are always advancing toward mined-out areas, but the roof is under excellent control.

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

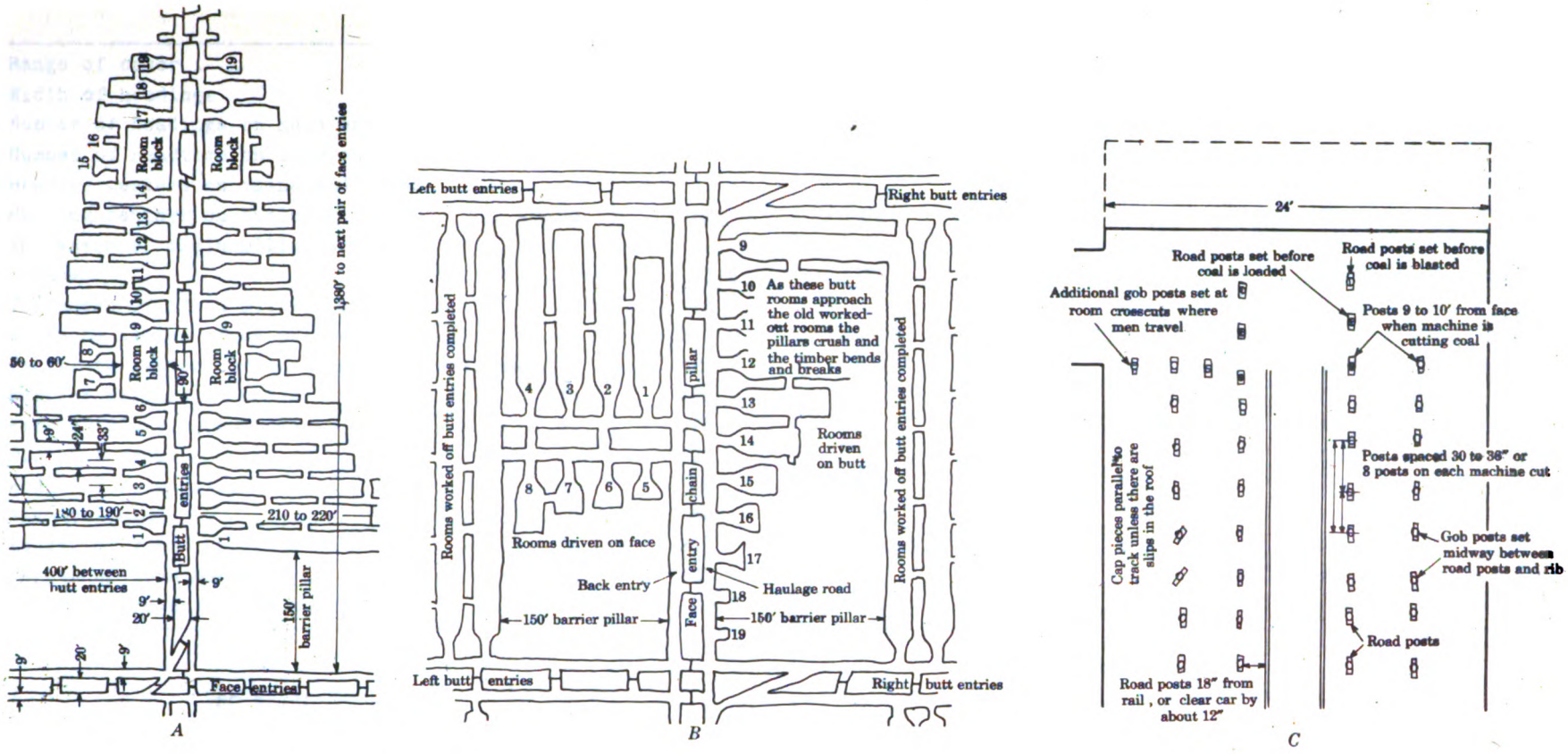

Figure 3.- Details of development and room timbering, type A mines: A, Room blocks left to protect butt entries under light cover in eastern Ohio; B, method of mining part of barrier pillars; C, plan of room timbering in a mine in Belmont County, Ohio.

Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 02:02 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 1.- Developmental distances and operating results for 13 mines in No. 8 field of eastern Ohio and the Panhandle district of West Virgina. Type A mines

Developmental distances	Mine in Belmont County (Mine 1)	Mine in Brooke County (Mine 2)	Seven mines, average cover less than 200 feet			Six mines, average cover greater than 200 feet		
			Maximum	Average	Minimum	Maximum	Average	Minimum
Range of cover, feet	[1]800-500-300	[1]300-175-0	350	121	0	800	400	90
Width of headings, do.	8 to 9	9	10	9.2	8	10	9.4	8
Number of headings on main entries	3	3 and 4	4	3	2	6	4	2
Number of headings on face entries	2	3 and 4	4	2	2	4	2	2
Heading centers on mains and faces, feet	32	30	40	32	29	80	45	33
Heading centers on butts, do.	32	30	40	33	29	50	39	30
Thickness of chain pillars on mains and faces, do.	23.5	21	30	23	20	70	36	21
Thickness of chain pillars on butts, do.	23.5	21	30	23	20	41	29	21
Distance between face entries, do.	1,200	1,300	1,950	1,350	1,050	1,400	1,175	1,000
Center to center distances of butt entries, do.	425	380	490	433	380	450	421	[2]350
Barrier pillars on mains, do.	200	200	200	162	80	450	251	200
Barrier pillars on faces, do.	175	100	200	141	80	200	173	150
Width of rooms, do.	24	24	26	24	24	24	24	22
Width of room pillars, do.	10	8	9	8	6	11	8.6	6
Room centers, do.	34	32	33	33	32	35	33	30
Length of room, do.	200	135 and 215	250	198	125	240	206	155
Length of room necks[3], do.	31	20	20	18	15	31	17	10
Width of protection on butt entry[4], do.	102.5	79	83	75	71	102.5	88	74

Operating results			Twelve hand-loading mines			Mechanical-loading mine
			Maximum	Average	Minimum	
Coal recovery, percent	62.3	65	65	57	55	55
Coal produced per day per man underground, tons	6.2	7.3	.....	5.4	.....	7.6
Coal produced per post used, do.	[5]4.4	3.95	.....	4.68	.....	4.63
Coal produced per pound of explosive, do.	(6)	10.5	.....	7.81	.....	4.88
Fatality rate per million tons of coal produced	0.91	3.60	.....	4.81	.....	3.21
Frequency rate for all injuries underground	179.7	25.96	.....	122.49	.....	130.2
Severity rate for all injuries underground	9.2	25.86	.....	23.68	.....	19.8

[1]Three values represent maximum, average, and minimum. [2]Does not include mines that turn rooms off one butt heading only. [3]Width of room necks is same as width of headings. [4]Consists of width of chain pillar, two headings, and two room stumps. [5]Estimated. [6]Not available.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

At a mine in Belmont County, Ohio, with 450 to 630 feet of cover, the rooms are turned off only one butt entry, thus the rooms are always advancing toward solid coal. Butt headings are not driven through to the next face entry and rooms are stopped 20 to 30 feet short of the next butt heading. Butt entries are developed in groups of four and the rooms on the outby entry of this group are not started until the rooms on the three pairs of inby butt entries are completed. The whole butt entry panel, 260 by 1,000 feet, thus acts as a safety block to prevent squeezes. On each butt entry half of the rooms (on the inby end) are driven 150 feet before the other half start, then all rooms are driven simultaneously.

A mine with an average cover of 400 feet in Marshall County, W. Va., was obtaining successful results by driving rooms 60 feet wide. Rooms are turned on 36-foot centers, but the room pillar of a pair of rooms is mined out after leaving a 40-foot room stump. A track is laid up each room neck and as a result two tracks are on each side of the 60-foot room. With rooms 24 feet wide, considerable trouble was experienced with roof falls in rooms, but with 60-foot rooms this trouble has been eliminated.

An attempt is made to recover some of the coal in the barrier pillars. The details of work vary but the general method of attack is shown in figure 3,B. It consists simply of driving rooms into the barrier pillars. In one section of a mine in Marshall County, W. Va., some room-pillar recovery was attempted. Here the rooms are turned off only one butt heading. The rooms are driven 155 feet long, 20 feet wide, and with a 14-foot pillar which is slabbed by two machine cuts after the room is driven. Other attempts have been made in this field to recover room pillars, but no systematic scheme, such as will be described subsequently, has ever been given a fair trial.

Coal is undercut by mining machines and in all mines 100 percent of the production is machine mined. The general practice is to work one miner to a place, or two men to two places This lack of concentration of workers results in a low daily production per room and, therefore, extensive development is required for a given daily mine tonnage.

Figure 3,C, illustrates an excellent system of room timbering for this type of mining. Table 1, together with the illustrations and the foregoing discussion, describe this system of mining. Critical comments on this method will be given after the other systems have been discussed.

Type B.- Full Advance with Pillar Extraction

The next step in a mining method is full advance with pillar extraction. This method is similar to Type A in the development of panels, but differs in that an attempt is made to recover all or part of room pillars, room stumps, and chain pillars, so that a greater percentage of recovery is attained. Type B represents a modification of type A which adapts it to use in coal lands of greater value from which a higher recovery is desired. Development methods are similar to those of type A except that thicker room pillars are left as the rooms are driven. The rooms are developed as the butt entry is driven, but as soon as the room reaches its limit, the extraction of the room pillar is begun. In some instances poor management allows rooms to stand for some time before an attempt is made to extract the pillars. Successive room pillars are mined in step back to the room stump. Rooms are turned off both butt headings. Thus on a butt entry the work may consist of driving the headings, advancing the rooms, and extracting the room pillars. The percentage of recovery is probably between 70 and 85 percent for this type of mining, but no accurate values were obtained.

Four mines of this type were studied in the Panhandle district of Pennsylvania, but they are representative of many mines using this type of development and pillar extraction. Two of the mines produced less than 1,000 tons per day and two more than 1,000 but less than 2,000 tons per day.

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

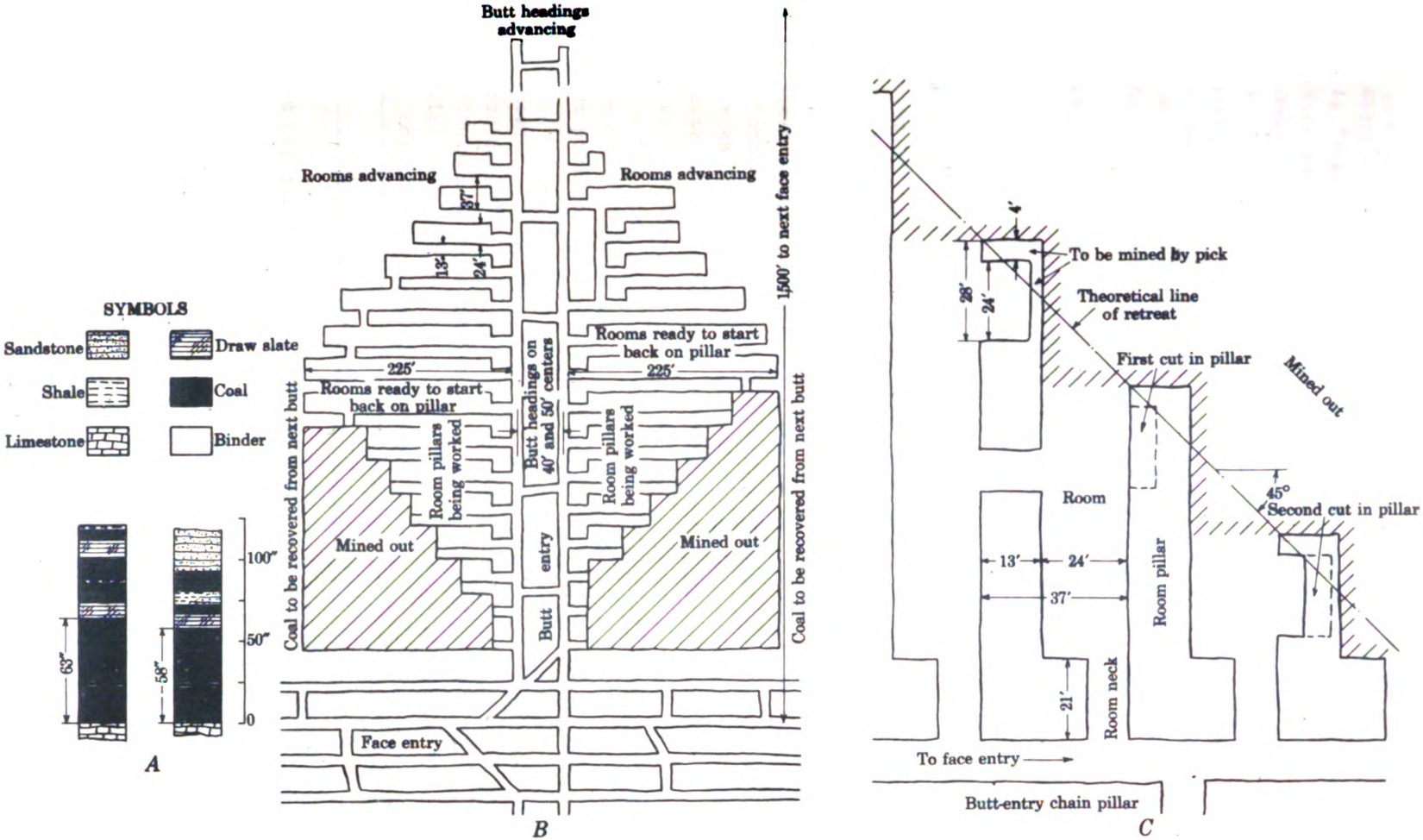

Figure 4.--Coal and roof sections, plan of development, and pillar extraction used in the Panhandle district of Pennsylvania, type B mines: A, Sections of the coal bed and immediate roof typical of type B mines; B, method of development and pillar extraction on a butt entry; C, details of extraction of room pillars.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The average thickness of the Pittsburgh coal bed in these four mines is 59 inches and varies locally from 56 to 63 inches. The draw slate varies in thickness from 4 to 30 inches, but the general average for all the mines is 13 inches; however, the average at individual mines varies from 9 to 22 inches. Above the draw slate, which is taken down as the face of the working place advances, is the usual roof coal with an average thickness of 9-3/4 inches; between the roof coal and the main roof are 9 to 15 feet of shales and thin laminated beds of coal. The main roof varies from a sandstone to a sandy shale and is 10 to 30 feet thick. Figure 4,A,gives some representative sections of the coal bed and the immediate roof.

In the area where this system is used the cover is light and it should be noted in Table 2 that the maximum cover is only 300 feet and the average cover is 95 feet. In three of the mines the development is largely controlled by outcrop lines.

TABLE 2.- Developmental distances and operating results for four mines in the Panhandle district of Pennsylvania. Type B mines

Developmental distances		Representative mine (Mine 3)	Range for four mines Max.	Avg.	Min.
Range of cover	feet	[1]250-125-65	300	95	5
Width of headings	do.	10 to 11	11	10.2	10
Number of headings on main entries		4	4	3	3
Number of headings on face entries		2, 3 and 4	4	3	2
Heading centers on mains, faces and butts	feet	40 and 50	50	44	40
Thickness of chain pillars on mains, faces and butts	do.	30 and 40	40	34	30
Distance between face entries	do.	1500	1800	1267	1000
Center to center distances of butt entries	do.	495	[2]650	[2]516	[2]450
Barrier pillars on mains	do.	40	125	72	40
Barrier pillars on faces	do.	20 and 40	125	51	20
Width of rooms	do.	24	24	23	21
Width of room pillars	do.	13	13	11	9
Room centers	do.	37	37	34	30
Length of rooms	do.	225	300	238	200
Length of room necks[3]	do.	21	21	19	18
Width of protection on butt entries[4]	do.	98	98	91	86
Width of pillar pocket	do.	20 to 24	24	17	12
Thickness of coal fender for pillar pocket	do.	3 to 4	8	4	1
Operating results					
Recovery	percent	80	[5]82.5		
Coal produced per day per man underground	tons	4.4	4.9		
Coal produced per post used	do.	4.78	[6]5.05		
Coal produced per pound of explosive	do.	6.8	[5]6.9		
Fatality rate per million tons of coal produced		2.38	0.60		
Frequency rate for all injuries underground		122.99	157.26		
Severity rate for all injuries underground		13.58	9.20		

[1]Three values represent maximum, average, and minimum values.
[2]Does not include mine driving rooms off one butt heading only.
[3]Width of room necks is same as width of headings.
[4]Consists of width of chain pillars, two headings, and two room stumps.
[5]For two mines only.
[6]For three mines only.

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Figure 4,B, shows the general plan of development and pillar extraction. Table 2 gives the details of development distances and operating results. The method is quite similar to type A except that rooms are a few feet narrower and room pillars are a few feet thicker; the room centers, however, are practically the same. Rooms are driven on sights at only one mine. The difference between the two types is that room pillars are extracted and some attempt is made to recover room stumps, chain pillars, and barrier pillars. Since the cover is light, the necessity for maintaining uniformly retreating pillar lines is not so essential as is the case where moderate to heavy cover is encountered. Figure 4,C, shows the standard method of pillar extraction. The general practice is to keep the pillars of 3 to 7 rooms retreating on an angle of approximately 45° with respect to the butt entry. With heavy cover many of the practices permissible at these mines would result in serious consequences.

As in type A, the development of squeezes along butt entries must be prevented. Chain pillars and room stumps provide this protection, at least while the rooms are being driven and the room pillars extracted. The total width of the two room stumps and the butt entry with its two headings and one chain pillar averages 91 feet and 71 feet, or 78 percent of this is solid coal; and this is for an average cover of only 95 feet. The methods of development for all four mines is well represented by figure 4,B; however, in one section of one of the mines, rooms were turned off only one butt heading. After the rooms and room pillars are extracted on a butt-entry panel, then the chain pillars and room stumps are removed, beginning at the inby end of the butt. Figure 5,A, shows the practice in mining chain pillars and room stumps at one of the mines; figure 5,B, shows the best practice for room timbering; and figure 5,C, shows details of pillar work and timbering in pillar places.

Mining machines are used to undercut the coal whenever possible, but that is not always practicable in pillar work. From 75 to 99 percent of the production at the individual mines is machine mined.

Type C.- Full Retreat with Short Fracture Lines

Full retreat with short fracture lines is a method of development and pillar extraction far superior to that used in type B, because it permits better roof control and concentration of work. In this type no rooms are driven or room pillars extracted until the butt entry is fully developed, then rooms are driven and pillars extracted. Room necks may be turned as the butts are developed. Room stumps and chain pillars are extracted in step with room pillars as the work retreats back to the face entries. The percentage of recovery is probably between 80 and 85 percent and could be higher except that often small pillar stumps are abandoned because their recovery would be hazardous. Only three mines using this system were studied: One in the northwestern part of Washington County, Pa., and the other two in the southeastern part of the same county. One of these mines produced 1,000 tons daily and the other two each produced about 5,200 tons daily. Since only three mines of this type were studied, the data with respect to each one will be given separately in table 3. These mines have been designated respectively as Nos. 4, 5, and 6.

At mine 4 the coal is 58 inches thick and at mines 5 and 6 the coal ranges in thickness from 66 to 69 inches. Figure 6,A, gives typical sections of the coal bed and immediate roof at these mines. As shown in table 3, it is well to bear in mind when considering the differences in development between these three mines that mine 4 has an average cover of 175 feet and mines 5 and 6 have an average cover of 500 and 600 feet, respectively.

Figure 6,B, gives the plan of development for mines 5 and 6. Development is similar at mine 4 except that its rooms are driven on 34-foot centers as compared to 45- and 90-foot centers for mines 5 and 6. Butt entries are fully developed before any rooms are turned except that the first two rooms off each butt heading are driven to facilitate ventilation.

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

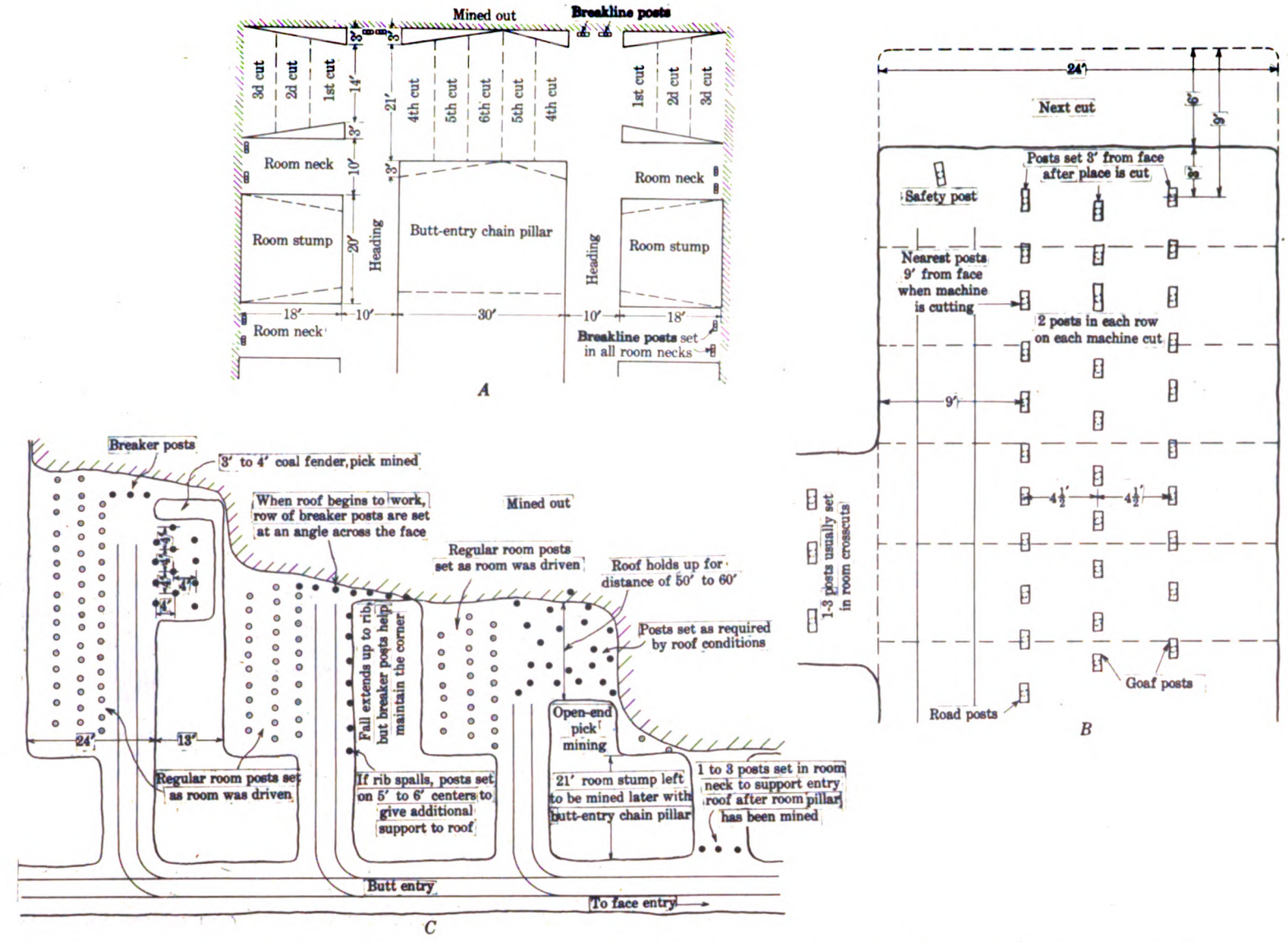

Figure 5.- Details of pillar extraction, room timbering, and timbering in pillar work, type B mines: A, Plan of recovering butt-entry chain pillars and room stumps; B, plan of room timbering; C, plan of rooms showing methods of pillar extraction and timbering in pillar places.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

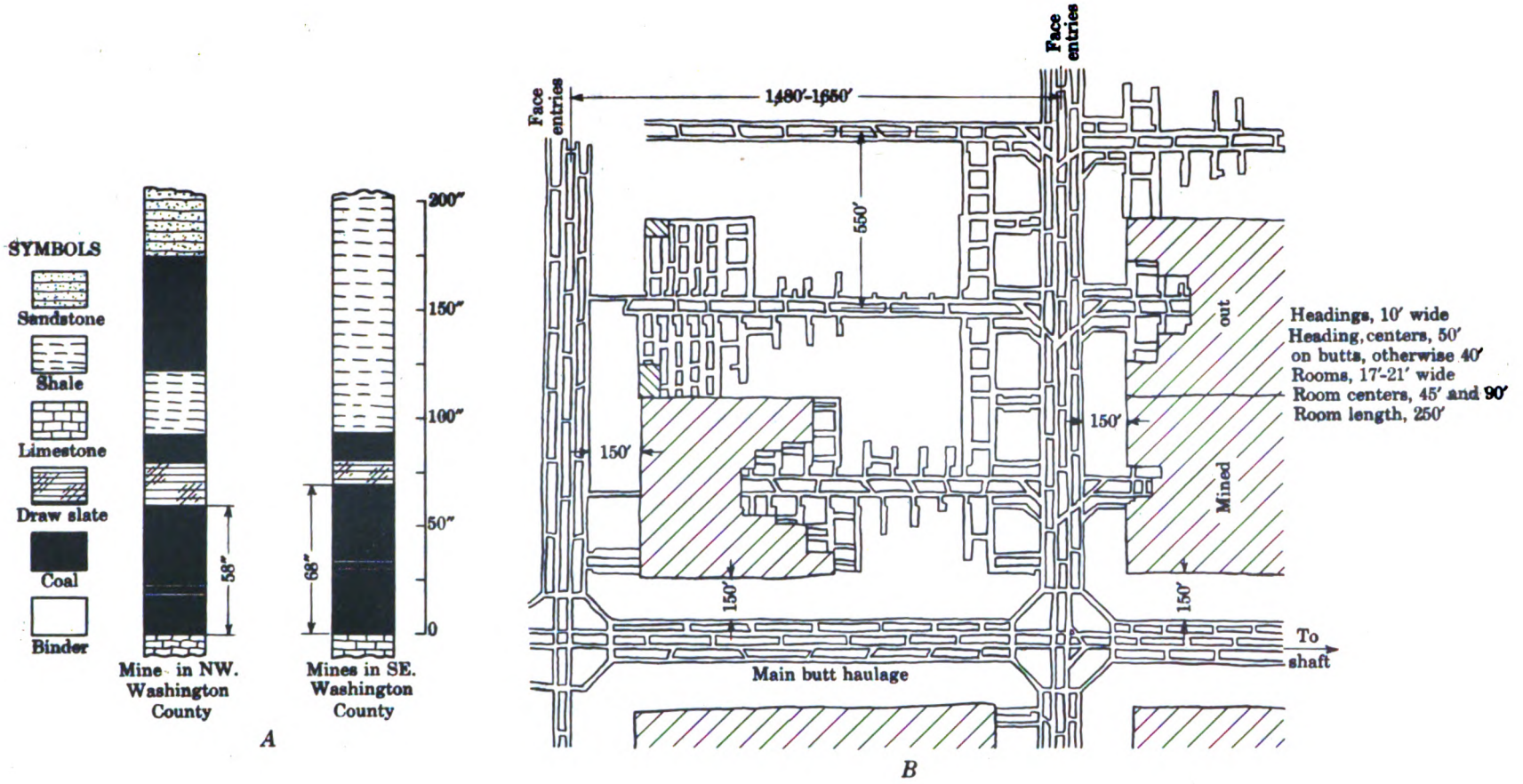

Figure 6.- Coal and roof sections and method of development when using full retreat with short pillaring lines, type C mines: A, Representative sections of the coal bed and immediate roof; B, plan of development and pillar extraction for a mine in the southeastern part of Washington County.

Original from THE OHIO STATE UNIVERSITY

After the butt entry is fully developed, rooms are started at the inby end and then, as soon as each room reaches its limit, pillar extraction begins. Room stumps and chain pillars are extracted in step with the room pillars. At mine 4 the extraction of chain pillars sometimes lags behind the extraction of room pillars. With light cover, this may not entail serious consequences, but the best practice is to maintain an even fracture line across rooms and chain pillars. This practice is carried out at mines 5 and 6 where serious trouble would develop because of the greater depth of cover if the extraction of chain pillars was allowed to lag behind the regular retreat of room pillars. At mine 4 the fracture line extends at an angle of 45° across three or four rooms, but at mines 5 and 6 the angle of retreat is at 27° 40' across four rooms.

TABLE 3.- Developmental distances and operating results for three mines in Washington County, Pa., using full retreat with short pillaring lines. Type C mines

Developmental distances	Northwestern part of county	Southeastern part of county	
	Mine 4	Mine 5	Mine 6
Range of cover[1] feet	240-175-90	900-500-250	845-600-355
Width of headings do.	10	10	10
Number of headings on main entries	5	4	6
Number of headings on face entries	3	3 and 4	2 to 6
Heading centers on mains feet	50	40	40
Heading centers on face do.	50	40	40 and 50
Heading centers on butts do.	50	50	50
Thickness of chain pillars on mains do.	40	30	30
Thickness of chain pillars on faces do.	40	30	30 and 40
Thickness of chain pillars on butts do.	40	40	40
Distance between face entries do.	1,500 to 1,800	1,480 to 1,650	1,400
Center to center distances of butt entries do.	450 to 550	550	550
Barrier pillars on mains do.	150	150	150
Barrier pillars on faces do.	100	150	150
Width of rooms do.	21	17 to 21	17 to 21
Width of room pillars do.	13	25 and 70	25 and 70
Room centers do.	34	45 and 90	45 and 90
Length of rooms do.	200 to 250	250	250
Length of room necks do.	18	25 to 30	30
Width of primary pillar pocket do.	20	17	17
Width of primary pillar fender do.	6	11	11
Width of secondary pillar pocket do.		21	21
Width of secondary pillar fender do.		9	9

Operating results	Mine 4	Average for mines 5 and 6	Average for all three mines
Recovery percent	85	85	85
Coal produced per day per man underground tons	4.63	7.89	7.44
Coal produced per post used do.	2.99	5.55	7.44
Coal produced per pound of explosives do.	Information not available		
Fatality rate per million tons of coal produced	1.77	1.86	1.83
Frequency rate for all injuries underground	99.03	66.20	77.14
Severity rate for all injuries underground	9.96	10.76	10.49

[1]Three values represent maximum, average, and minimum values.

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Because of the lighter cover, rooms are turned on 34-foot centers at mine 4, but on 90-foot centers at mines 5 and 6; however, the first six inby rooms at the latter two mines are turned on 45-foot centers. This is done to speed up the initial production from the butt entry. At mines 5 and 6 the room width may vary from 17 to 21 feet. This is because the clean-up system is used and the places are cut each day according to the ability of the miners to load coal. All rooms are driven on sights. In figure 6,B, note the method of development used at the intersection of main entries to avoid numerous small chain-pillar blocks.

Figure 7 illustrates details of pillar extraction and timbering in rooms and pillar places.

Bottom cutting machines are used at all three mines. At mine 4, 95 percent of the coal is machine mined; at mines 5 and 6 an average of 70 percent of the coal is machine mined.

Type D.- Half Advance and Half Retreat

The half-advance and half-retreat system is so called because as the butt entries are driven the rooms are turned off one heading and, after the rooms reach their limit the room pillar is mined. After the butt entry has reached its limit the rooms off the other heading are driven, starting at the inby end of the butt entry. The pillars of these rooms and the chain pillar and room stumps of both headings are then mined as the work retreats to the face entry. The rooms on the advance side are driven 50 to 90 feet longer than those on the retreat side. This is done because on the advance there is considerable solid coal for protection against squeezes; whereas on the retreat work the pillar extraction can be done quicker by having shorter rooms. The recovery varies from 72 to 90 percent, with an average of 82 percent for six of the mines.

This method of development is used principally in those parts of Allegheny and Washington Counties south of Pittsburgh. Seven mines using this system were studied. Six of the mines produced 1,500 to 2,000 tons daily and the seventh about 3,100 tons daily.

The coal bed varies in thickness from 56 to 93 inches. The average thickness for six of the mines is 62 inches and for the seventh mine is 93 inches. The immediate roof consists of the usual draw slate and roof coal and the main roof is generally a hard shale. The draw slate averages 12 inches in thickness for the seven mines. The general range in thickness of draw slate at individual mines is 5 to 15 inches; however, at two of the mines a maximum of 3 and 6 feet of draw slate was observed. Beds of coal and shale are found between the draw slate and the main shale roof. The total thickness varies from 10 inches to 4-1/2 feet. The thickness of the roof coal directly over the draw slate varies from 2 to 22 inches and averages 11 inches. The average cover varies from 125 to 400 feet. Figure 9,A, shows typical coal and roof sections.

Figure 8 shows the general plan of development and table 4 gives the details of development, pillar extraction, and operating data. Two typical mines are selected for this group.

Roof control is obtained by leaving rather substantial chain pillars and room stumps on the advance; one mine has a chain pillar 54 feet wide. The critical point, insofar as roof control is concerned, comes when the change is made from advance to retreat on the individual panel. Too often extraction of the chain pillar and room stumps lags behind extraction of room pillars, with the result that these stumps extend into the gob, start squeezes, and much coal is lost. Another mistake is to develop too many rooms ahead of the pillar work so that rooms must stand some time before their pillars are mined. When used with moderate cover, close attention to limiting the solid development, and rapid extraction of pillars in proper step, this system works satisfactorily. Fracture lines are short and generally extend across four to seven rooms, depending upon the length of the rooms, because the pillars retreat in steps of 25 to 50 feet.

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

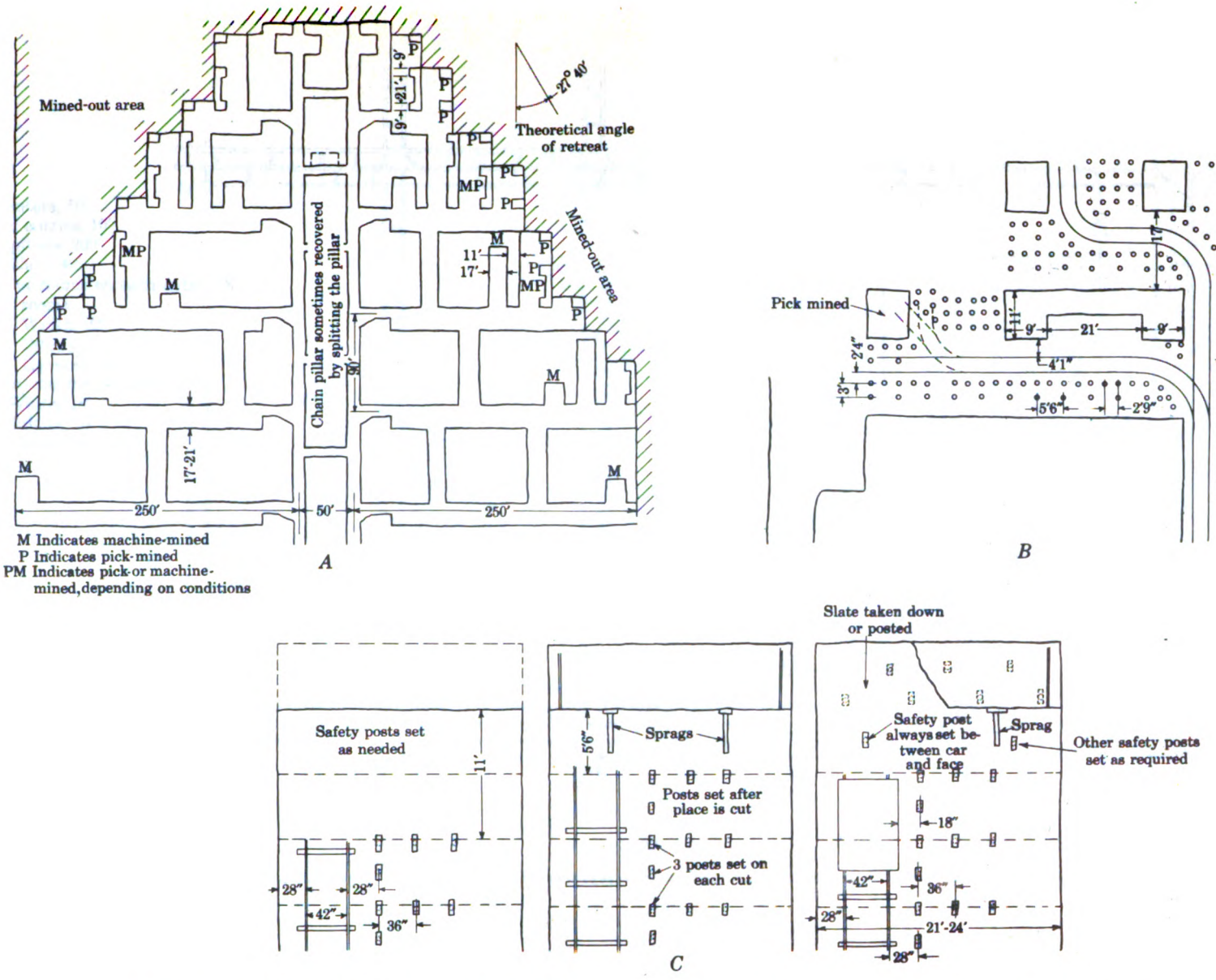

Figure 7.- Details of pillar extraction and timbering, type C mines: A, Details of pillar extraction on butt entry; B, details of timbering in pillar work; C, method of timbering in rooms.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

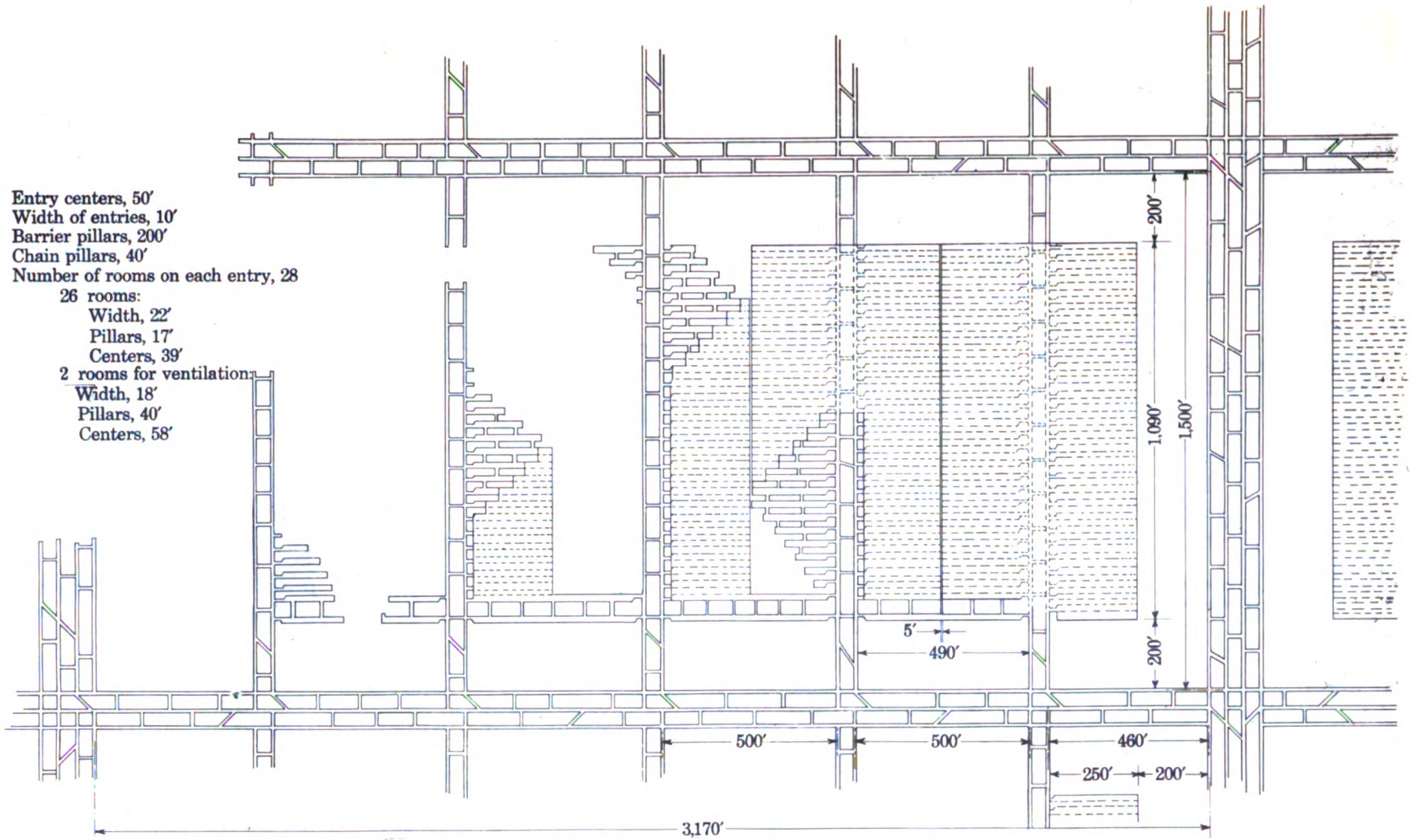

Figure 8.- Method of development of mines using the half-advance and half-retreat system of pillar extraction, type D mines.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

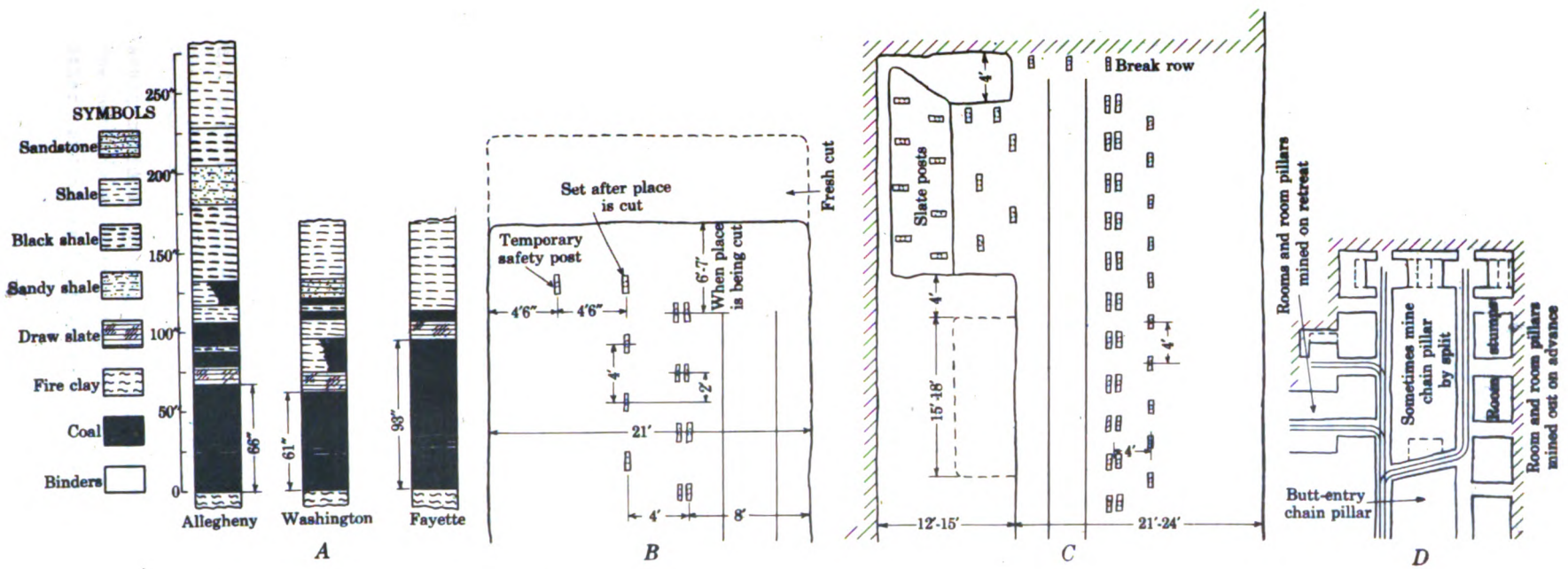

Figure 9.- Details of coal and roof sections, timbering, and pillar extraction, type D mines: A, Representative sections of coal bed and immediate roof of mines in group D in Allegheny, Fayette, and Washington Counties, Pa.; B, plan of room timbering; C, timbering in pillar pockets; D, method of extracting chain pillars and room stumps.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 4.- Developmental distances and operating results for mines using the half-advance and half-retreat system in Allegheny and Washington Counties, Pennsylvania. Type D mines

Developmental distances	Mine in Allegheny County (Mine 7)	Mine in Washington County (Mine 8)	Range for seven mines		
			Maximum	Average	Minimum
Range of cover[1] feet	400-300-200	400-250-25	600	284	25
Width of headings do.	10	11	11	10.6	10
Number of headings on main entries	4	4	4	4	3
Number of headings on face entries	3 or 4	2 or 4	4	3	2
Heading centers on mains and faces feet	50	40	50	47	40
Heading centers on butts do.	50	40	65	49	40
Thickness of chain pillars on mains and faces do.	40	29	40	37	29
Thickness of chain pillars on butts do.	40	29	54	38	29
Distance between face entries do.	1,400 to 1,950	1,450	1,950	1,539	1,200
Center to center distances of butt entries do.	480	550	550	496	435
Barrier pillars on mains do.	200	100	300	146	90
Barrier pillars on faces do.	200	100	200	120	90
Width of rooms do.	21	24	24	22.3	18
Width of room pillars do.	18	15	27	16	12
Room centers do.	39	39	45	39	36
Length of rooms, on advance[2] do.	275	280	350	281	270
Length of rooms, on retreat[3] do.	200	200	220	181	100
Length of room neck[4] do.	24	21	30	23	18
Width of pillar pocket do.	17	19	22	17.5	15
Width of pillar fender do.	6	4	6	5	4
Operating results					
Recovery percent	86	90	[5]82.0		
Coal produced per day per man underground tons	4.80	3.03	3.89		
Coal produced per post used do.	4.81	5.51	5.63		
Coal produced per pound of explosives used do.	11.3	12.3	[6]9.5		
Fatality rate per million tons of coal produced	4.16	4.11	3.98		
Frequency rate for all injuries underground	79.33	135.82	142.02		
Severity rate for all injuries underground	20.67	12.10	18.81		

[1]Three values represent maximum, average, and minimum values.
[2]Rooms driven off one heading as butt entry advances.
[3]Rooms driven off other heading as butt entry work is retreating.
[4]Room necks same width as entries.
[5]For six mines only.
[6]For three mines only.

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The method of timbering illustrated in figure 5,B, is used at one of these mines. Figure 9 shows further details of pillar extraction and timbering. From 83 to 97 percent of the production is undercut by machine.

Type E - Full Retreat with Long Fracture Lines

In the method of mining by full retreat with long fracture lines the area to be mined is first developed into panels by main-butt haulage roads and face entries. Panel sizes vary and depend upon many factors, but an average panel would be 1,200 to 1,600 feet wide by 1,800 to 2,400 feet long. Butt entries are driven off the face entries, starting at one end of the panel, but no rooms are turned until the butt entry is completed. Rooms are turned off one butt heading only, and as soon as the room is completed, the extraction of the room pillar begins. The rooms are driven in step and timed so that as soon as they are completed their pillars can be extracted in step with a general rib line. The pillars are mined in step with the rib line, making an angle of 45° or less with the butt entries. The length of the rib line depends upon the size of the panel. Room stumps and chain pillars are mined in step with the general rib line.

Forty-one mines studied in western Pennsylvania and the Fairmont district of West Virginia were using this system of mining. With the variable natural conditions encountered over this large area it is to be expected that the methods used should differ in detail. A subclassification of type E can be made on the basis of size of room pillars, as follows:

1.- Pillars developed on the block system, or, rooms on 50- to 125-foot centers.

2.- Medium room pillars developed, or, rooms on 33- to 50-foot centers.

Another classification is based on the method of mining pillars by (1) the customary pocket-and-stump method or by (2) the open-end system. Still another classification is possible on the basis of whether pillars are mined by butt pockets only or by alternate butt and face pockets.

To describe these 41 mines they will be grouped primarily on a geographical basis which to some extent is also a classification according to the details of mining.

Figure 10,A, shows the plan of development for some mines in Washington and Westmoreland Counties, Pa., with rooms on centers of 50 feet or less and with room pillars 13 to 29 feet wide. These are discussed under group A of type E (See p.15). Figure 10,B, shows the plan of development for mines in which the rooms are driven on centers of 50 to 80 feet with room pillars 40 to 60 feet wide. This method is used in Westmoreland, Fayette, Washington, and Greene Counties, Pa., and in the Fairmont field of West Virginia. Mines of this type are described under groups B, C, and D of type E. Figure 11,A, represents the block system of development used by mines in the Fairmont district of West Virginia and the coking district of Pennsylvania and are described under groups C, D, and E of type E. Figure 11,B, represents a type of development used by some mines in Pennsylvania and West Virginia in which chain pillars for all entries are developed in blocks of the same size as room-pillar blocks. Note that the angle of retreat is less than 45° with respect to the butt entries. Figures 10 and 11 are taken from maps of individual mines and therefore represent special conditions; however, they are representative of all mines in type E. For open-end mining, the type of development may vary but would follow some plan such as shown in figures 10,B, 11,A, and 11,B. As seen from these illustrations, the general plan of development by main-butt haulage roads and by face and butt entries does not vary very much. The principal variation occurs in the method of pillar recovery. These details will be discussed as each group of type E is described.

Generated on 2024-09-18 02:02 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

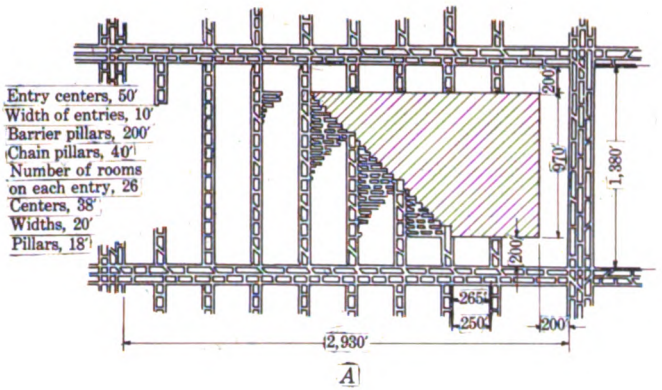

Figure 10.- General plans of development, type E mines: A, Plan of development and pillar extraction for mines driving rooms on centers of 50 feet or less, typical of mines in group A; B, plan of development and pillar extraction for mines driving rooms on centers of 50 feet or more, typical of mines in groups B, C, and D.

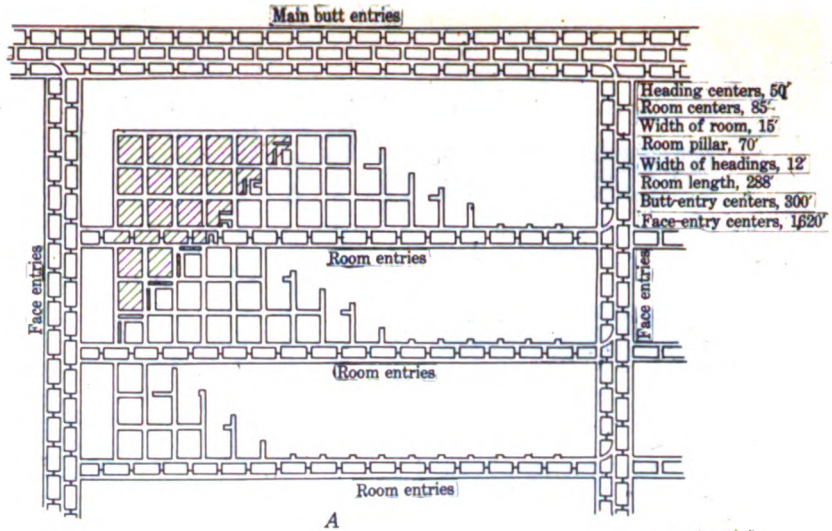

Figure 11.- General plan of development, type E mines: A, Development and pillar extraction using the block system typical of mines in the coking district of Pennsylvania and the Fairmont district of West Virginia; B, development by driving all solid work narrow and on 100- to 125-foot centers, typical of some mines in groups B, C, D, and E.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

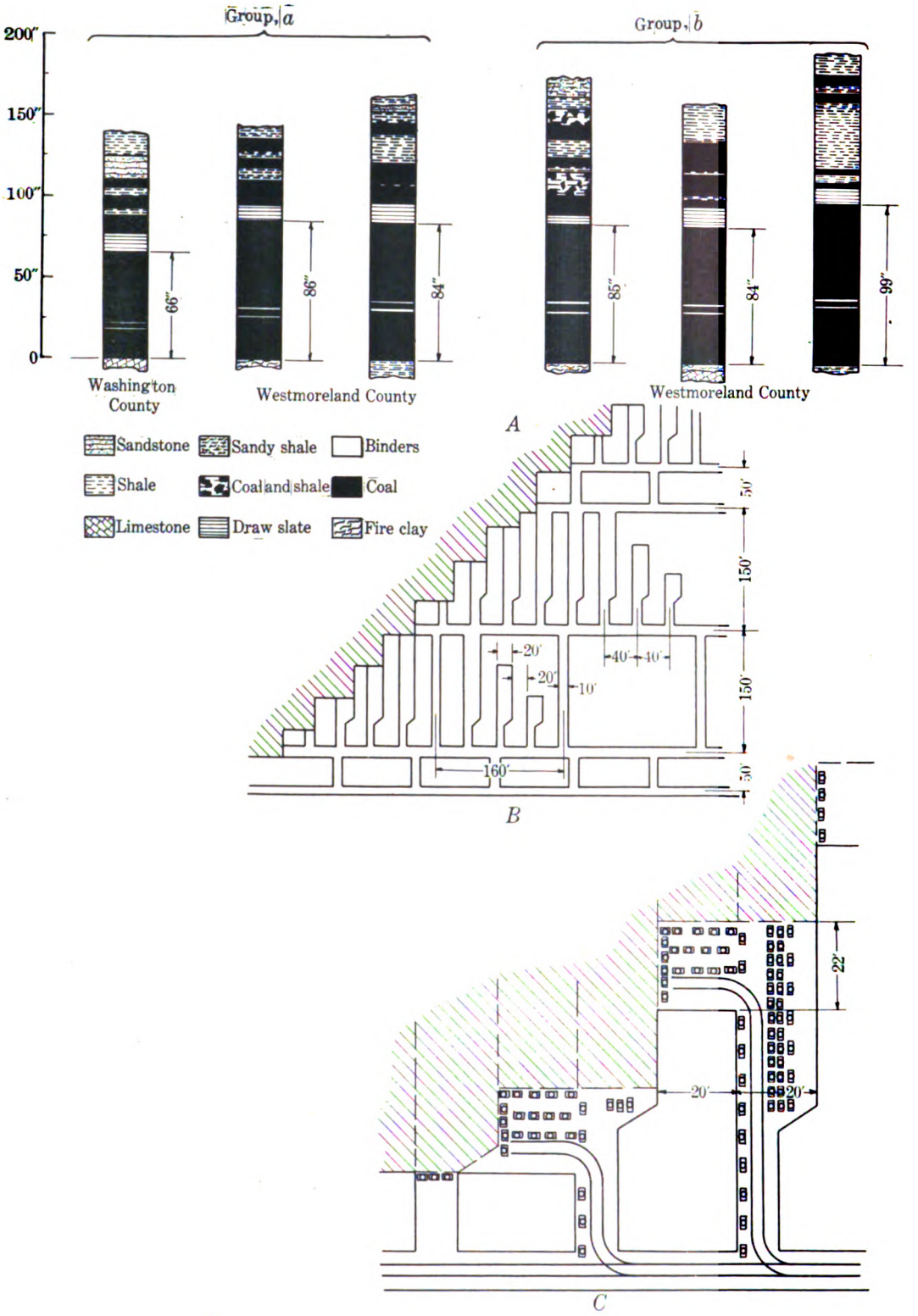

Figure 12.- Coal and roof sections, details of development, pillar extraction, and timbering for mines of group A, type E, in Washington and Westmoreland Counties, Pa.: A, Representative sections of the coal bed and immediate roof for mines in groups A and B of type E located principally in Westmoreland County, Pa.; B, development for pillar line using a subbutt heading, mine in Westmoreland County, Pa.; C, details of pillar extraction and timbering in pillar places for mine illustrated in B.

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

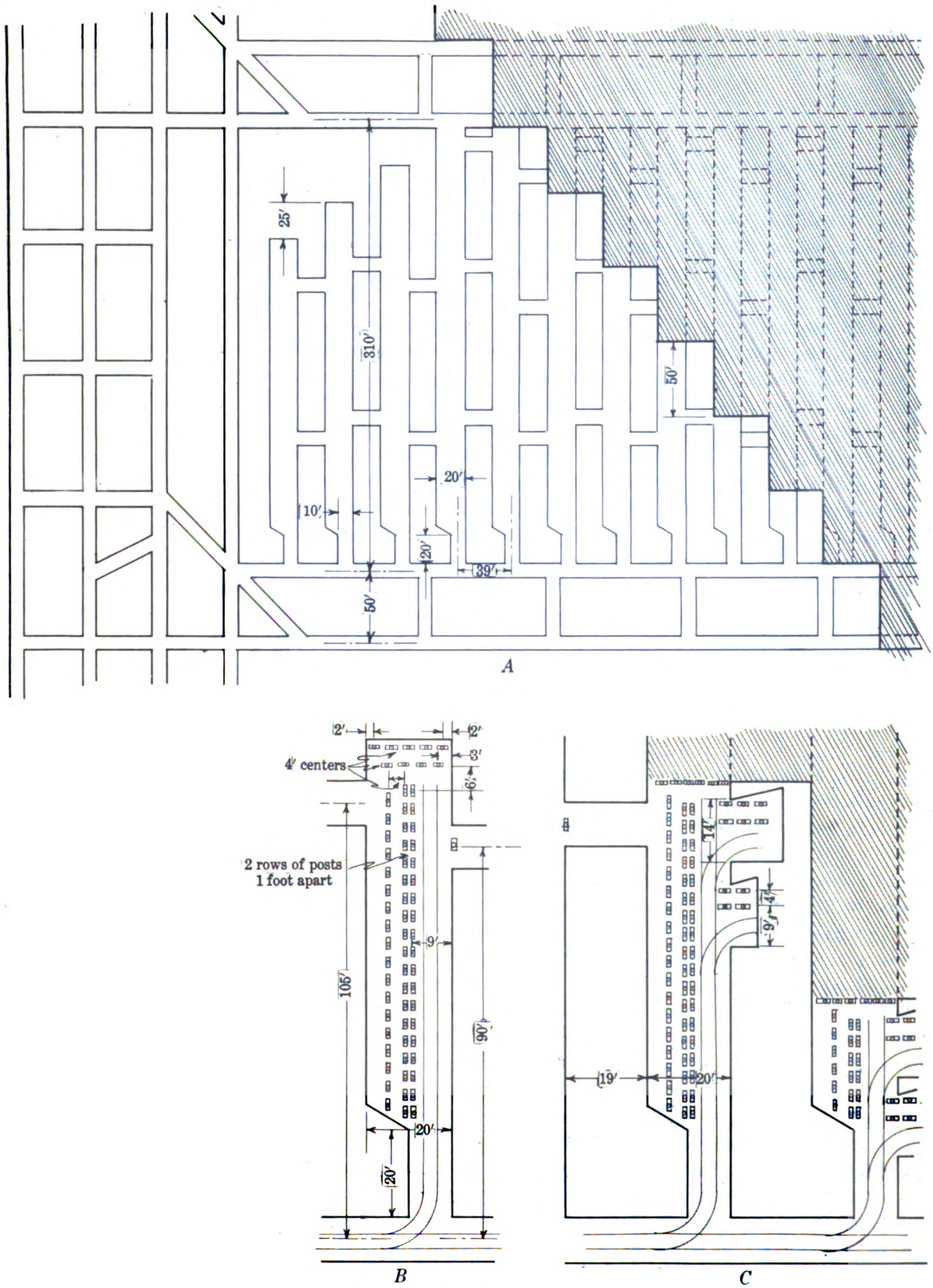

Figure 13.- Details of development, pillar extraction, and timbering for a mine in Westmoreland County, group A, type E: A, Details of development and pillar extraction; B, plan of posting roof and draw slate in rooms; C, plan showing sequence of operations in room-pillar recovering and timbering.

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Group A of Type E

Group A consists of six mines, four in Westmoreland County near Greensburg and two in the northern part of Washington County. This group is distinguished from others of the same type by the fact that rooms are developed on centers of 50 feet or less and are driven 18 to 21 feet wide with pillars 13 to 29 feet wide. Recovery ranges from 85 to 90 percent. Two of the mines produce less than 1,000 tons, two produce between 1,000 and 2,000 tons, one produces 2,500 tons, and one 3,600 tons per day.

The Pittsburgh coal bed in the four mines in Westmoreland County averages 82 inches in thickness. The draw slate varies in thickness from 6 to 12 inches, with an average of 9 inches. The roof coal averages 15 inches in thickness and varies from 9 to 28 inches but, when attaining its maximum thickness, it usually contains many thin beds of shale. Between the roof coal and the main roof, which varies from a shale to a sandstone, are alternate beds of coal and shale having a total thickness of 30 to 55 inches. In the two mines in Washington County the coal and immediate roof is rather uniform, consisting, in ascending order, of 65 inches of coal, 10 inches of draw slate, 16 inches roof coal, 33 inches of shale and coal, and a main roof of shale. Figure 12,A, shows representative sections of the coal bed and roof for these mines in group A and for mines in group B which also are in Westmoreland County. In general, the coal bed is flat, but in a few of the mines in Westmoreland County there are local pitches where the coal reaches a maximum dip of 5 to 6 percent. The average cover at the individual mines ranges from 65 to 400 feet, and it should be noted that the development and extraction of thin pillars is best suited for light to moderate cover.

Figure 10,A, shows the general plan of development and the extraction of the pillars along definitely planned rib lines. Table 5 gives the development distances and operating results of this group of mines.

Because of the moderate cover, roof control is not difficult in these mines. At one mine having a maximum cover of 550 feet the butt entries are on 350-foot centers, but a split panel entry or subbutt heading is driven so that short rooms can be used and the pillars recovered immediately. (See figure 12,B.) When the rooms were driven 300 feet in length considerable trouble was experienced with the roof in the rooms before the room pillar was extracted. By driving shorter rooms this trouble has been eliminated. At this same mine the pillars are mined open end by pick work, but this is not the same open-end system of pillar extraction as used in the coking region where the open-end pillar places are cut by machine. Figure 12,C, shows the method of timbering in pillar places for this same mine. Another mine with a maximum cover of only 100 feet drives 10-foot rooms on 100-foot centers as the butt entry is driven, thus obtaining greater initial production as the butt develops. fter the butt entry is completed and pillar work begins, two additional rooms are driven in the pillars, thus reducing the centers to 33-1/3 feet. This system is possible with light cover and with an immediate roof which can be supported for a definite period of time without the necessity for retimbering. Figure 13,A, shows the details of pillar work. Note that the rooms advance in steps of 25 feet and the pillars retreat in steps of 50 feet. Figures 13,B and C, show the methods of timbering in rooms and pillar places for this same mine.

Coal is undercut by machines at all mines and varies from 51 to 90 percent of the production. The pillars are recovered by driving pockets by machine and leaving thin stumps or fenders which are mined by machine if possible and otherwise by pick. Pillar lines retreat at an angle of 45° with respect to butt entries, although in one mine the angle is 52° and at another the angle is 24° with respect to the butt entry.

Generated on 2024-09-18 02:03 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 5.- Developmental distances and operating results for a group of six mines using a full-retreat system with narrow room pillars. Group A of type E

Developmental distances	Representative mine (Mine 9)	Range for six mines		
		Max.	Avg.	Min
Range of cover, feet	[1]400-300-80	550	240	10
Width of headings, do.	10	10	10	10
Number of headings on main entries	4	4	4	2
Number of headings on face entries	3	4	3	2
Heading centers on mains, feet	60	60	52	40
Heading centers on faces, do.	60	60	53	50
Heading centers on butts, do.	50	60	52	50
Thickness of chain pillars on mains, do.	50	50	42	30
Thickness of chain pillars on faces, do.	50	50	43	40
Thickness of chain pillars on butts, do.	40	50	42	40
Distance between face entries, do.	1450	2400	1287	700
Center to center distances of butt entries, do.	250	400	307	250
Barrier pillars on mains, do.	200	200	156	75
Barrier pillars on faces, do.	200	200	144	75
Width of rooms, do.	18	21	19.5	18
Width of room pillars, do.	15	29	18.5	13
Room centers, do.	33	50	38	33
Length of rooms, do.	200	320	260	200
Length of room neck[2], do.	15	30	18	13
Width of pillar pocket, do.	12	21	14	10
Width of pillar fender, do.	4	10	5.4	4
Angle of retreating rib lines with respect to butt entries, degrees	45	52	45	24
Operating results				
Recovery, percent	90	[3]88		
Coal produced per day per man underground, tons	5.14	5.89		
Coal produced per post used, do.	4.68	4.76		
Coal produced per pound of explosive used, do.	No information			
Fatality rate per million tons of coal produced	.86	1.69		
Frequency rate for all injuries underground	27.74	128.73		
Severity rate for all injuries underground	.21	9.13		

[1]Three values represent maximum, average, and minimum values.
[2]Width of room neck same as for headings.
[3]For three mines only.

Group B of Type E

Group B comprises eight mines in Westmoreland County. This group differs from Group A principally in that rooms are driven 10 to 20 feet wide on 60- to 100-foot centers, thus leaving pillars 44 to 90 feet thick. There is no definite information on recovery for this group, but it probably ranges from 80 to 90 percent. Three of the mines produce 1,000 to 2,000 tons daily and five produce 2,000 to 3,000 tons daily.

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

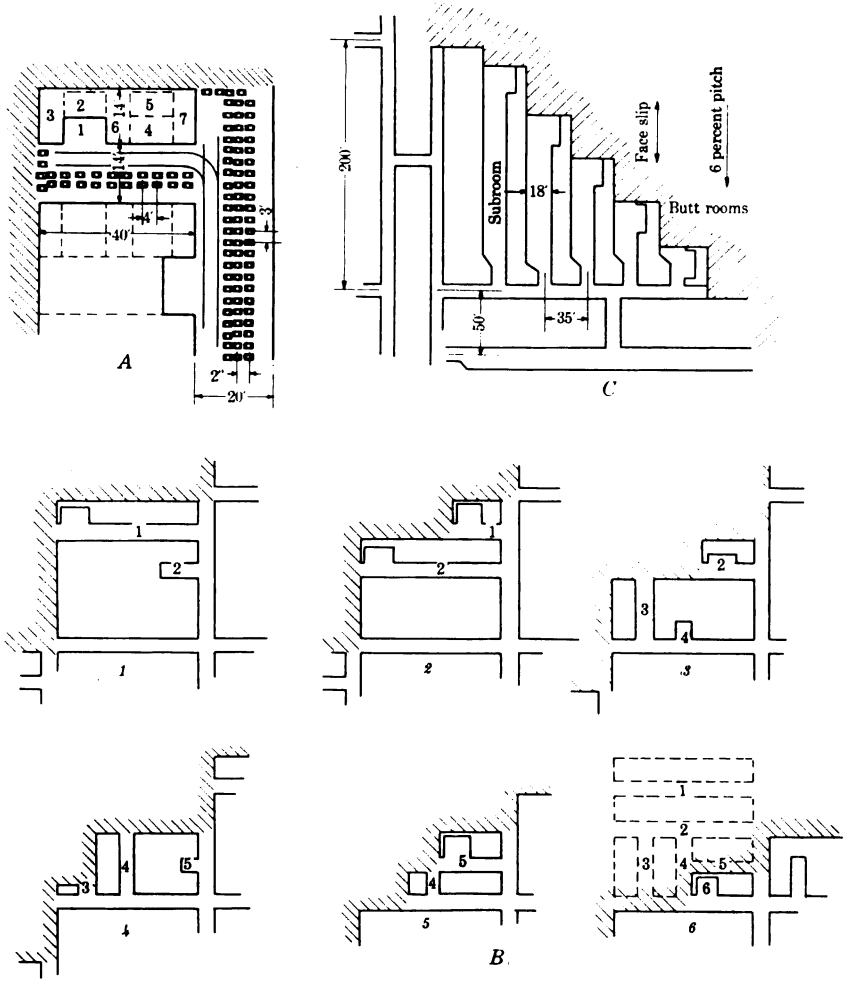

Figure 14.- Details of pillar extraction and timbering in pillar work for mines in Westmoreland County, group B of type E: A, Plan showing sequence of removing room pillars and position of timbers; B, six steps in sequence of operations in extracting a 90-foot block of coal; C, modification of regular system of mining by driving subrooms to avoid any difficulties from local pitches of the coal bed.

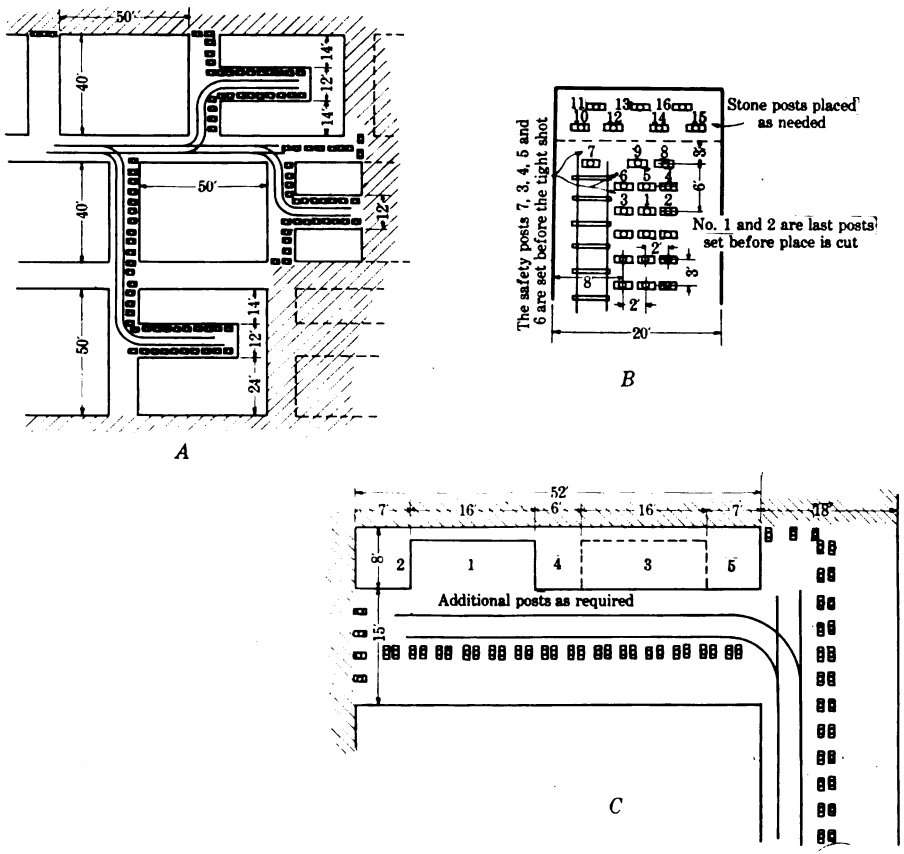

Figure 15.- Details of pillar extraction and timbering mines, group B of type E: A, Plan showing sequence of removing entry chain pillars and barrier and entry stumps between caved areas; B, sketch showing position of timber upon completion of loading the coal in a room (numbers indicate order of placing timber); C, plan of room-pillar process of removal, with location of timber and breakline posts.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The Pittsburgh coal bed varies in thickness from 72 to 99 inches, with an average of 84 inches for the eight mines. The draw slate averages 10 inches and the roof coal averages 11 inches in thickness. The main roof varies from a shale to a hard sandy shale. Between the roof coal and the main roof 30 to 70 inches of laminated coal and shale are found. Figure 12,A, shows representative coal and roof sections. In general, the coal is flat, although there are extensive areas in these mines where the dip is as much as 6 percent, and some variations are made in development on account of these grades. Rooms are driven on the face, but fairly often the main haulage roads and face entries are driven without respect to cleats to obtain better haulage grades. The average cover at the individual mines ranges from 250 to 350 feet, the maximum cover being 500 feet at one mine.

Figure 10,B, is representative of the general plan of development of seven of the mines of this group; figure 11,B, is representative of the eighth mine. Table 6 gives details of developmental distances and operating results. At seven of the mines, room pillars are recovered by driving butt pockets only off the rooms. This method is illustrated in figure 14,A, which shows the extraction of a butt pocket 14 feet wide with a 14-foot fender. After the pocket is completed the fender is mined by secondary pockets and the small secondary fender is mined by pick. At one of the mines where the pillars are developed in blocks 90 feet square, alternate butt and face pockets are driven off rooms and crosscuts, respectively Figure 14,B, shows six of the steps in the sequence of mining pillars by this method.

At two of the mines horsebacks in the roof are fairly prevalent and add to the roof hazards. They parallel the butt cleats, and therefore if rooms were driven on the face cleats they would extend the length of the room. Consequently, the development is planned so that rooms are driven on the butt cleats and thus cut across the horsebacks at right angles After a room is developed, the position of all horsebacks is known and the pillar pockets then can be driven to avoid them. This is an example of the application of good engineering judgment to the reduction or minimizing of natural hazards and also to the reduction of cost of mining. Another example of good engineering judgment in this group of mines is the method of development used in those parts of the mines where the dip of the coal bed is as much as 6 percent. Figure 14,C, shows the development for these conditions. By driving the rooms up the pitch rather than at right angles to the pitch, both drainage and cutting are facilitated, and the mining of the rooms and room pillars can be as rapid as with normal conditions, and a uniform rib line can be maintained.

At one of the mines, rooms were driven on 120-foot centers as the butt entries were developed, but when the rib line retreated, much of the roof in these rooms had fallen. The pillars were then split by new rooms on 60-foot centers and, in some cases, old rooms which had not caved too badly were cleaned. The fact that rooms were driven on 120-foot centers enabled the management to get out of a difficult situation, but this shows the advisability of not driving any rooms too far ahead of the retreating rib lines.

Figure 15,A, shows the method of extracting chain and barrier pillars. Figure 15,B and C, shows a representative plan of room timbering and timbering in a pillar pocket.

At some of these mines all working places are driven on sights. From 40 to 90 percent of the production is machine mined, and at three of the mines the coal is top cut.

Group C of Type E

Group C is composed of seven mines in Fayette, Greene, and Washington Counties; six are within a radius of 12 miles of Brownsville and one is near Washington, Pa. The type of development is similar to group B except that in the extraction of pillars alternate butt and face pockets are used more frequently. Recovery is high and averages 85 percent. These are all large mines, four producing 2,000 to 3,000 tons, one 3,900 tons, and the other 5,100 tons per day.

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 6.- Developmental distances and operating results for a group of eight mines in Westmoreland County using a full-retreat system with wide room pillars. Group B of type E

Developmental distances	Representative mine (Mine 10)	Range for six mines		
		Maximum	Average	Minimum
Range of cover[1] ..... feet	[1]300-250-200	500	294	10
Width of headings ..... do.	10	10	10	10
Number of headings on mains	7	7	4	2
Number of headings on faces	2 and 3	6	3	2
Heading centers on mains and faces ..... feet	50	100	56.5	40
Heading centers on butts ..... do.	50 and 60	100	54	40
Thickness of chain pillars on mains and faces ..... do.	40	90	46.5	30
Thickness of chain pillars on butts ..... do.	40 and 50	90	44	30
Distance between face entries ..... do.	1000	2000	1059	700
Center to center distances of butt entries ..... do.	410	410	297	250
Barrier pillars on mains ..... do.	50 to 90	200	120	50
Barrier pillars on faces ..... do.	80	100	89	70
Width of rooms ..... do.	20	20	17	10
Width of room pillars ..... do.	40	90	54	40
Room centers ..... do.	60	100	73	60
Length of rooms ..... do.	340	340	250	160
Length of room necks[2] ..... do.	21	40	20	15
Width of primary pillar pocket ..... do.	14 to 16	18	14.5	10
Width of primary pillar fender ..... do.	14	14	11.8	7
Width of secondary pillar pocket ..... do.	12	24	18.4	12
Width of secondary pillar fender ..... do.	5	8	5	3
Angle of retreating rib line with respect to butt entries ..... degrees	45	60	45	17
Operating results				
Recovery ..... percent	[3]No accurate information			
Coal produced per day per man underground ..... tons	7.6	10.0	6.8	5.44
Coal produced per post used ..... do.	9.6	9.6	6.5	2.8
Coal produced per pound of explosive used ..... do.	11.3	13.8	9.4	5.5
Fatality rate per million tons of coal produced	4.87	4.87	1.97	.....
Frequency rate for all injuries underground	252	252	101.9	48.2
Severity rate for all injuries underground	21.0	25.8	15.25	4.24

[1]Three values represent maximum, average, and minimum values.
[2]Room necks same width as entries.
[3]See text.

The Pittsburgh coal bed varies in thickness from 66 to 101 inches, being thickest near Uniontown and thinning out toward Washington. The draw slate varies in thickness from 5 to 36 inches and averages 13.8 inches. The mines east of the Monongahela river have no roof coal, but in its place have a black shale of variable thickness (9 to 60 inches); west of the river the roof coal is usually present and averages 12 inches in thickness. The main roof varies from a sandstone to a shale. Figure 16,A, gives representative sections of the

Generated on 2024-09-18 02:03 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

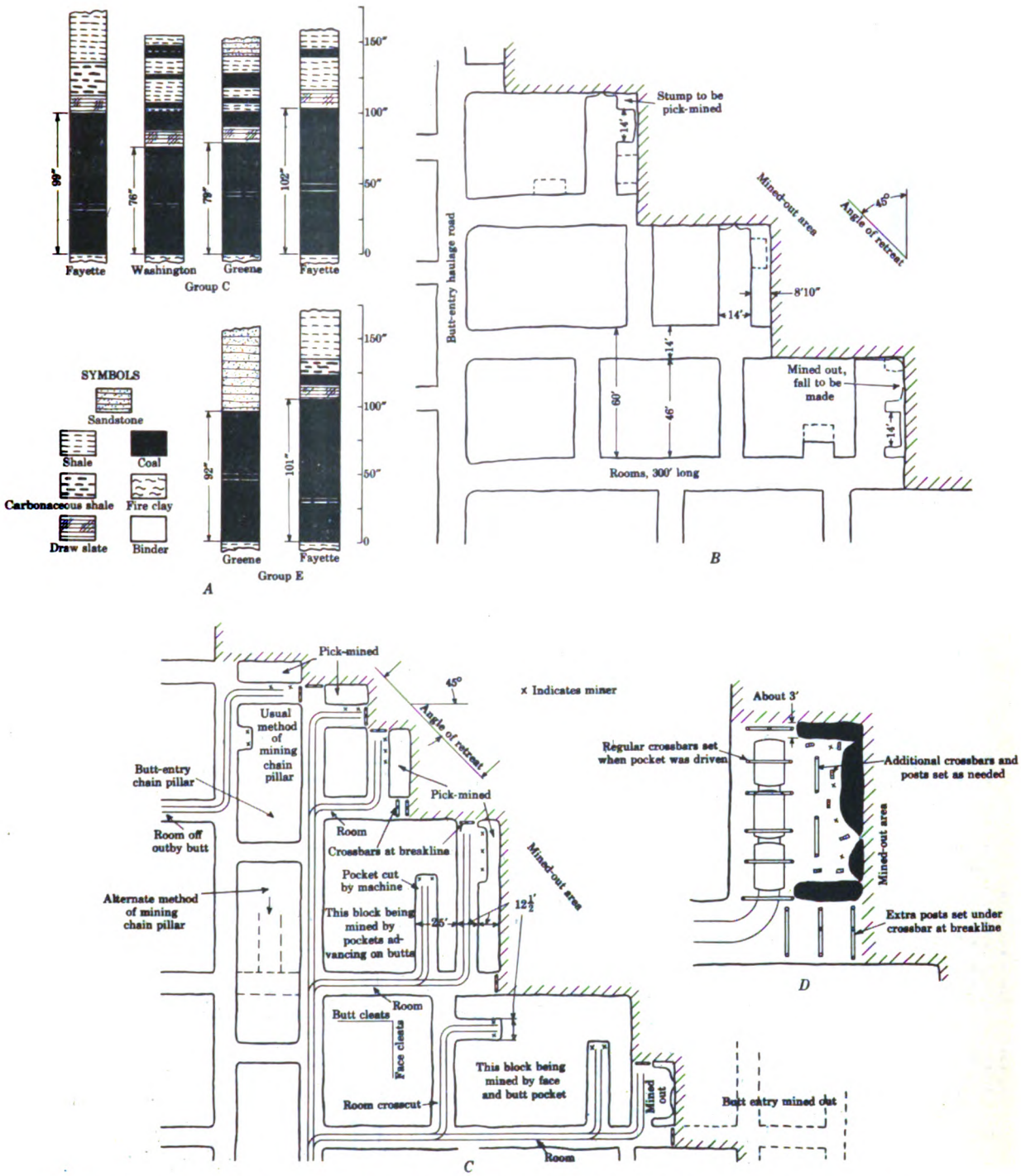

Figure 16.- Coal and roof sections and methods of pillar extraction for mines in Fayette, Greene, and Washington Counties, Pa., group C, type E: A, Representative sections of coal bed and immediate roof, groups C and E, type E mines; B, method of pillar extraction by butt pockets only for rooms on 60-foot centers; C, method of pillar extraction for rooms on 100-foot centers; D, details of timbering in pillar pockets (same mine as shown in 16 C).

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

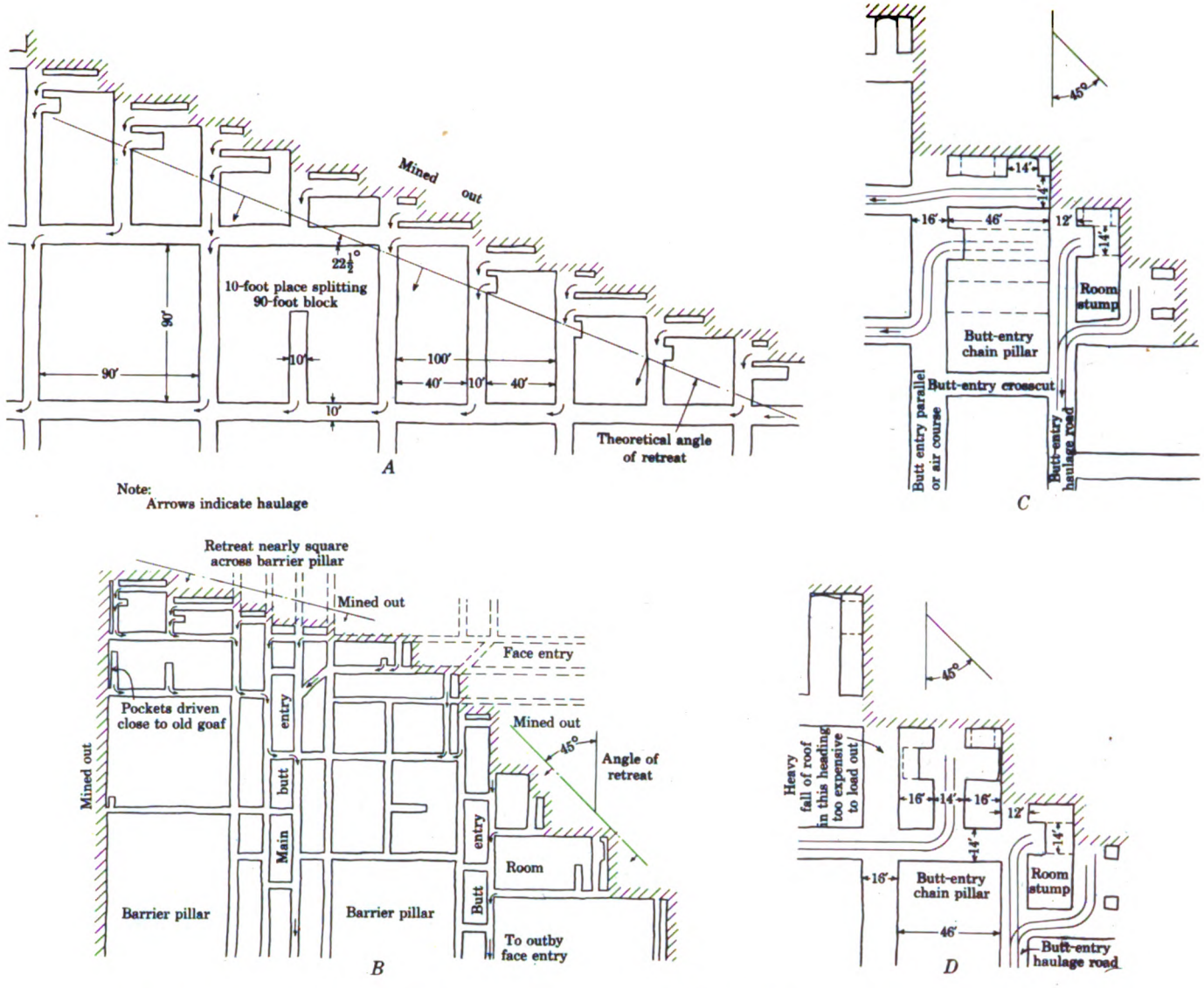

Figure 17.- Details of pillar extraction, group C, type E mines: A, Pillar recovery for rooms on 100-foot centers with pillaring line at angle of 22 1/2 °; B, method of mining barrier pillars in step with pillaring line in adjoining panel; C, general method for recovery of butt-entry chain pillars and room stumps; D, special method for recovery of chain pillars and room stumps.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

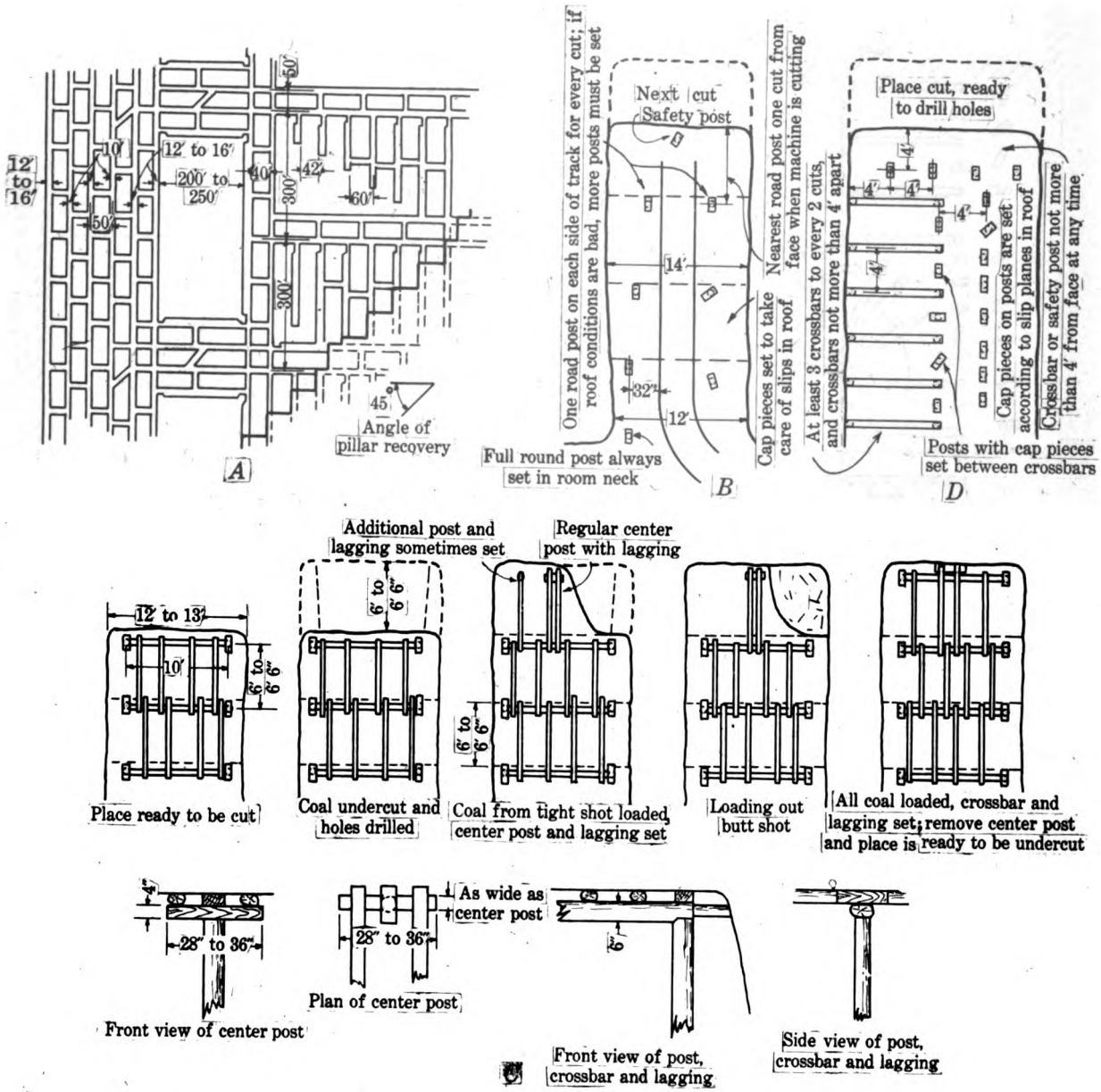
12' to 16'
10'
12' to 16'
200' to 250'
40'
42'
50'
300'
60'
300'
50'
45°
Angle of pillar recovery
A
One road post on each side of track for every cut; if roof conditions are bad, more posts must be set
Next cut
Safety post
14'
32"
12'
Full round post always set in room neck
B
Cap pieces set to take care of slips in roof
Nearest road post one cut from face when machine is cutting
At least 3 crossbars to every 2 cuts, and crossbars not more than 4' apart
Place cut, ready to drill holes
4'
Cap pieces on posts are set according to slip planes in roof
Crossbar or safety post not more than 4' from face at any time
Posts with cap pieces set between crossbars
D
Additional post and lagging sometimes set
Regular center post with lagging
12' to 13'
10'
6' to 6' 6"
Place ready to be cut
Coal undercut and holes drilled
Coal from tight shot loaded, center post and lagging set
Loading out butt shot
All coal loaded, crossbar and lagging set; remove center post and place is ready to be undercut
4"
28" to 36"
Front view of center post
28" to 36"
Plan of center post
As wide as center post
6'
Front view of post, crossbar and lagging
Side view of post, crossbar and lagging

Figure 18.- Details of development and room timbering, group C, type E mines: A, Plan of development using subface and subbutt entries; B, room timbering using posts only; C, room timbering using crossbars supported by posts; D, room timbering using crossbars supported by posts and props.

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

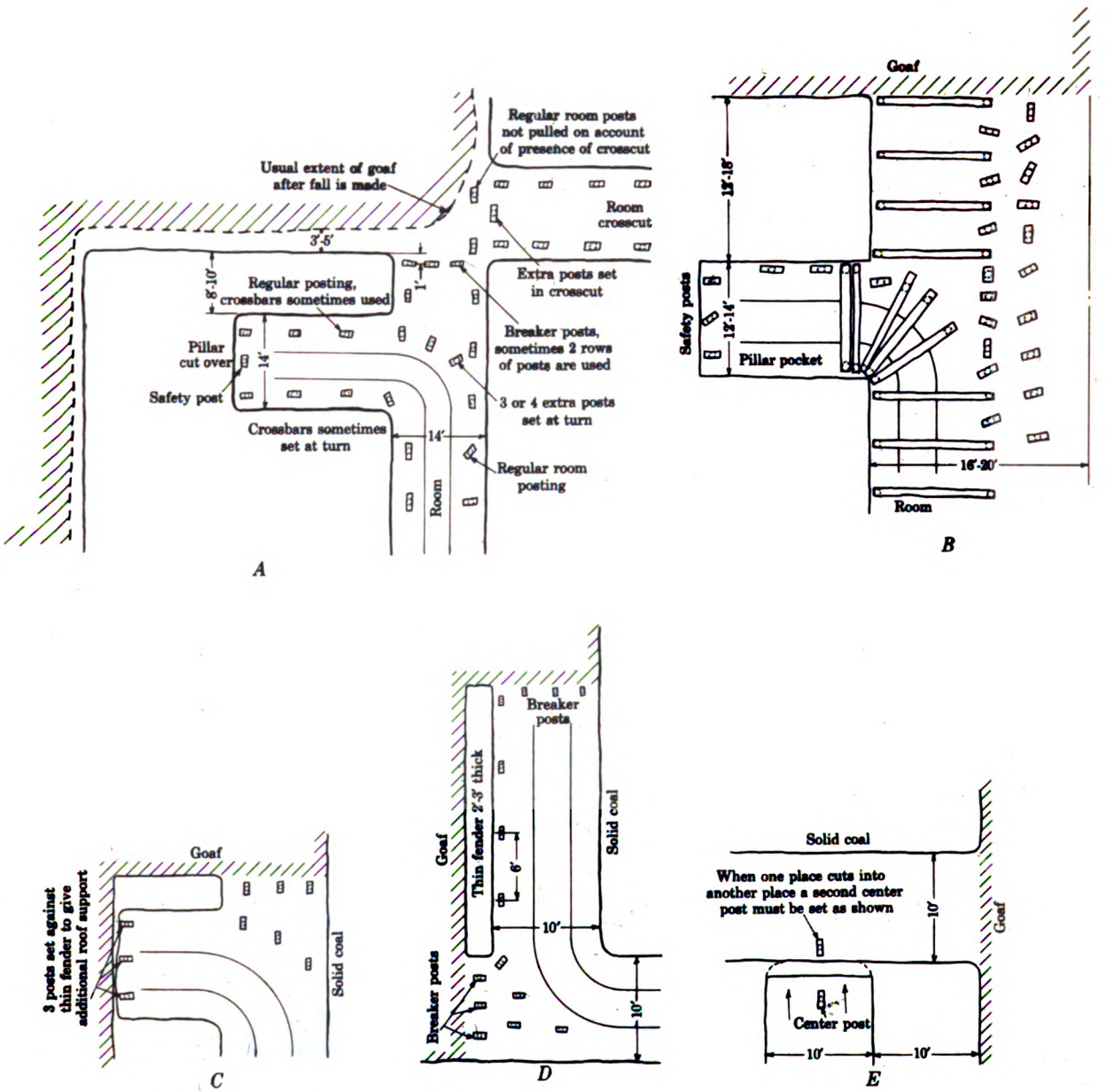

Figure 19.- Details of timbering in pillar work, group C, type E mines: A, Timbering in pillar places using posts only; B, timbering with crossbars and posts in pillar places; C, details of pillar timbering at goaf line; D, details of pillar timbering with thin fenders; E, details of pillar timbering when cutting into adjoining room.

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

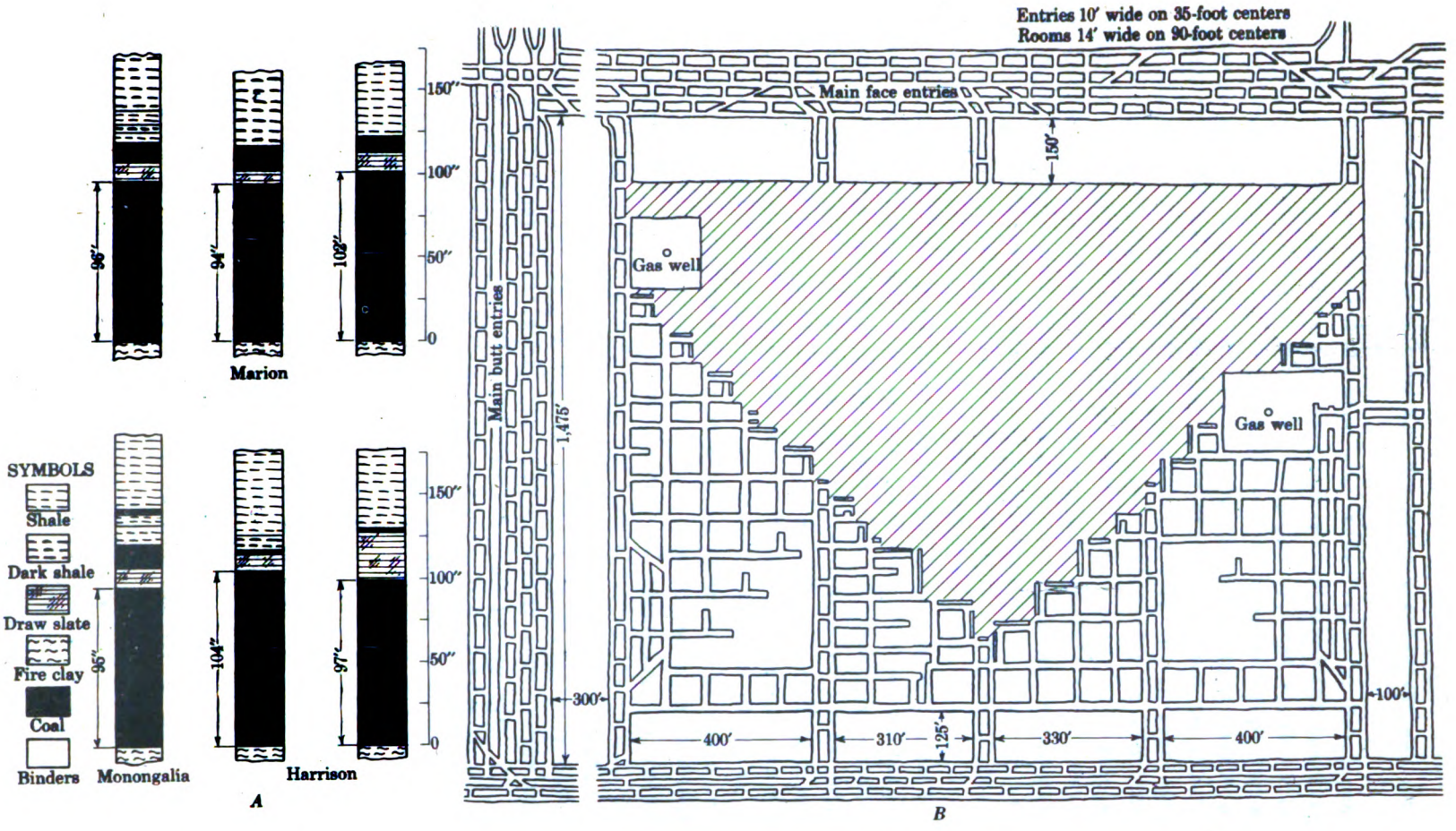

Figure 20.- Coal and roof sections in the Fairmont district of West Virginia and a special method of development, group D, type E mines; A, Representative sections of the coal bed and immediate roof in Harrison, Marion, and Monongalia Counties, W. Va.; B, special plan of development and pillar extraction to increase production from a panel.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

coal bed and immediate roof in Fayette, Greene, and Washington Counties, in which counties are the mines of groups C and E, type E. The average cover varies from 300 to 625 feet with a maximum of 800 feet at one mine.

Figures 10,B, 11,A, and 11,B, show the general plan of development for this group of mines. Table 7 gives the details of development distances and operating results.

The general practice is to have the rib lines retreat at an angle of 45° with respect to face and butt entries. Figure 16,B, shows the details of pillar extraction for a mine with rooms on 60-foot centers. All pockets are driven on butt cleats off the rooms. Figure 16,C, shows the details of extraction for a mine with rooms on 100-foot centers. At this mine some pillars are recovered with butt pockets only and in some cases both butt and face pockets are used. Figure 16,D, show details of timbering in a pillar pocket at this same mine. Figure 17,A, shows the details of pillar extraction for a mine with rooms on 100-foot centers but with the pillaring line at an angle of 22-1/2° to the butt entries.

An important feature of type E is that barrier pillars, chain pillars, and room stumps can be recovered. Whenever possible, barrier pillars are mined in step with the pillaring line of the adjoining panel as shown in figure 17,B. Figure 17,C and D, shows the usual methods of recovery of chain pillars. While Figure 17,B, C, and D, shows the practice in mines of group C, the same general practice is followed at all type E mines.

At one of the mines butt entries are turned on 600-foot centers off the face entries. After leaving a barrier pillar of 200 to 250 feet, subfaces are driven with an intermediate butt entry turned off these subfaces on 300-foot centers. This method of development is shown in figure 18,A; it has the advantage of assisting ventilation and concentrating haulage, particularly as the rib line retreats along the barrier pillar.

At these mines 6 to 12 inches of top coal is left in place to help support the draw slate. Timbering in rooms and pillar pockets consists only of posts in some mines, of crossbars supported by posts in other mines and in some cases of a combination of crossbars and posts. Figure 18,B, C, and D, shows details of timbering for rooms and pillar pockets. Whenever the pillar pockets are driven the same width as the rooms, the method of timbering is usually the same in both. With the system of mining represented by type E, systematic and complete roof support in all working places is essential for safety and high recovery. Figure 19 shows further details of timbering in pillar work. From 59 to 90 percent of the coal is machine mined. At two of the mines the coal is top cut.

Group D of Type E

All of the mines studied in Monongalia, Marion, and Harrison Counties of the Fairmont district of northern West Virginia are included in group D. The methods of development are similar to groups B and C, but these mines are discussed separately, principally on the basis of geographical situation. Rooms are developed on 50- to 100-foot centers and the pillars are recovered principally by alternate butt and face pockets. Recovery is generally high and averages 83 percent. Fourteen mines were studied; three produced less than 1,000 tons, four between 1,000 and 2,000 tons, five between 2,000 and 3,300 tons, and two 6,000 tons per day, by working two shifts daily.

The Pittsburgh coal bed varies in thickness from 85 to 114 inches and averages 100 inches in the 14 mines studied. Based on the mines observed, the average thickness in each County is 93 inches in Monongalia County, 100 inches in Marion County, and 102 inches in Harrison County. The draw slate is variable; it averages 16 inches but varies from 2 to 48 inches and sometimes is entirely missing. The roof coal is also variable; it averages 8-1/2 inches but varies from 1 to 14 inches and sometimes is missing. The main roof varies from a thick shale to a sandstone. Figure 20,A, represents typical coal and roof sections in the Fairmont district. The average cover varies from 150 to 525 feet with a maximum cover of 900 feet at two mines.

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 7.- Developmental distances and operating results for a group of seven mines in Fayette, Greene, and Washington Counties, Pa., using a full-retreat system with wide room pillars. Group C of type E mines

Developmental distances	Representative mine using 60-foot room centers, (Mine 11)	Representative mine using 100-foot room centers, (Mine 12)	Range for seven mines		
			Maximum	Average	Minimum
Range of cover, feet	550-450-270	530-310-200	800	419	253
Width of heading, do.	12	12	14	11.7	10
Number of headings on mains	4 and 5	4 and 5	7	5	3
Number of headings on faces	3 and 4	3 and 4	6	4	3
Heading centers on mains, faces and butts, feet	60	50	100	60	50
Thickness of chain pillars on mains, faces and butts, do.	48	38	90	48	37
Distance between face entries, do.	1,400	1,100 to 1,600	2,400	1,418	1,100
Center to center distances of butts, do.	360	300	360	337	300
Barrier pillars on mains, do.	120 to 240	150 to 500	500	226	100
Barrier pillars on faces, do.	140 and 200	170 and 200	450	195	100
Width of rooms, do.	14	12.5	18	14.5	10
Width of room pillars, do.	46	87.5	90	73	42
Room centers, do.	60	100	100	88	60
Length of rooms, do.	300	250	300	282	240
Length of room necks[2], do.			21	20	18
Width of primary pillar pocket, do.	14	12.5	18	13.5	10
Width of primary pillar fender, do.	8 to 10	12.5	18	9.8	3
Width of secondary pillar pocket, do.	14	[3]15 to 25	18	(3)	10
Width of secondary pillar fender, do.	5	3	5	(3)	3
Angle of retreating rib line with respect to butt entries, degrees	45	45	45	45	22-1/2
Operating results					
Recovery, percent	87.5	75		84.7	
Coal produced per day per man underground, tons	5.7	5.2		6.2	
Coal produced per post used, do.	6.68	3.72		5.2	
Coal produced per pound of explosive used, do.	6.12	7.72		8.45	
Fatality rate per million tons of coal produced	1.41	0.54		2.79	
Frequency rate for all injuries underground	67.72	64.67		113.84	
Severity rate for all injuries underground	7.38	6.13		15.94	

[1]Three values represent maximum, average, and minimum values. [2]Width of room neck same as entries except for rooms 14 feet or less in width; room neck is same width as room. [3]Size of secondary pillar pocket and fender varies depending on roof conditions at the time the pillar is mined.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

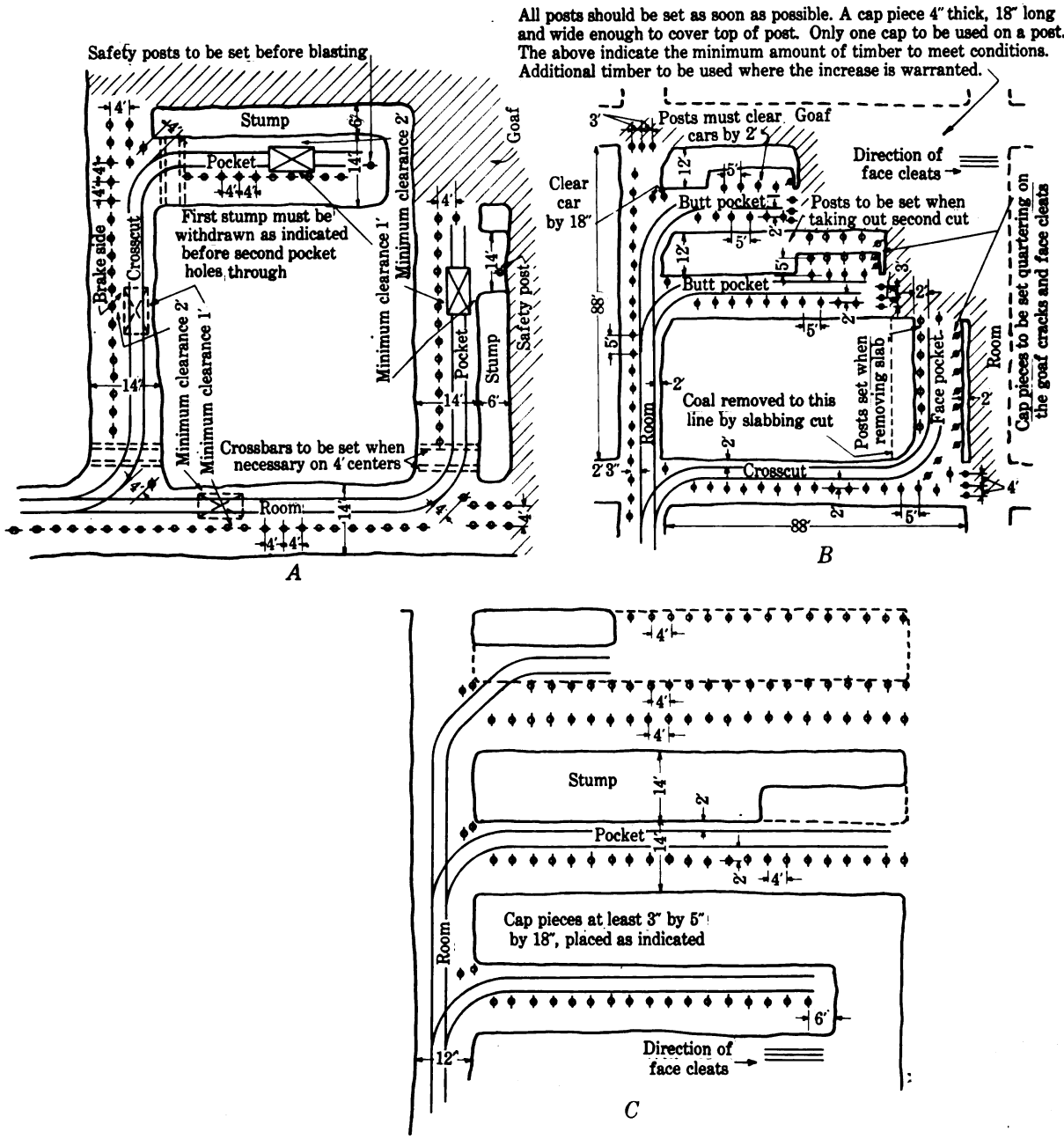
All posts should be set as soon as possible. A cap piece 4" thick, 18" long and wide enough to cover top of post. Only one cap to be used on a post. The above indicate the minimum amount of timber to meet conditions. Additional timber to be used where the increase is warranted.
Safety posts to be set before blasting
Stump
Pocket
Goaf
Brake side
Crosscut
First stump must be withdrawn as indicated before second pocket holes through
Minimum clearance 1'
Minimum clearance 2'
Minimum clearance 2'
Minimum clearance 1'
Pocket
Stump
Safety post
Crossbars to be set when necessary on 4' centers
Room
A
Posts must clear cars by 2'
Goaf
Direction of face cleats
Clear car by 18"
Butt pocket
Posts to be set when taking out second cut
Butt pocket
Coal removed to this line by slabbing cut
Posts set when removing slab
Face pocket
Room
Room
Cap pieces to be set quartering on the goaf cracks and face cleats
Crosscut
B
Stump
Pocket
Cap pieces at least 3" by 5" by 18", placed as indicated
Room
Direction of face cleats
C

Figure 21.- Details of pillar extraction and timbering, group D, type E mines: A, Method of pillar extraction and timbering when mining 76-foot blocks of coal by alternate butt and face pockets; B, method of extraction of pillar blocks by alternate butt and face pockets, but with variation in the width of coal fender; C, method of extracting pillar blocks by butt pockets only, slabbing the fender by machine.

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Figure 11,A, is representative of the general plan of development for mines of this group. Table 8 gives the details of developmental distances and operating results for two typical mines and the average for the 14 mines. Figure 20,B, shows a method for working two rib lines in one panel to increase the rate of production from the panel. At all of these mines the retreat of the pillaring lines is at an angle of 45° to the butt entries.

Figure 21,A, shows the usual method of pillar recovery and timbering in pillar pockets at those mines where the pillar blocks are mined by alternate butt and face pockets. Note that the fenders are 6 feet wide for both butt and face pockets. Figure 21,B, shows a variation in that fenders for face pockets are only 2 feet wide, whereas fenders for butt pockets are 12 feet wide. It is claimed that by taking into consideration the effect of cleats on the strength of the fender, better roof control along the pillaring lines is obtained. When pillar blocks are mined by butt pockets only, the methods used are similar to those described for groups A, B, and C of type E. Figure 21,C, shows a slight variation in that the 14-foot fender is slabbed by two machine cuts. Timbering in solid work and pillar places consists largely of posts only, but in some mines crossbars are also used. Top coal is usually left in place to help support the draw slate.

From 70 to 100 percent of the coal is machine mined, the average being 84 percent for all the mines. At three of the mines the coal is top cut.

Group E of Type E

The six mines in group E are developed in essentially the same way as those of groups B, C, and D; they differ, however, in the use of the open-end system of pillar extraction. The estimated recovery for these six mines is 87 percent. They are all in Pennsylvania, one in Greene County, four in Fayette County, and one in Westmoreland County. Three of these produced between 1,000 and 2,000 tons, one between 2,000 and 3,000 tons, one between 3,000 and 4,000 tons, and one produced 5,000 tons daily.

The coal bed varies in thickness from 78 to 104 inches and averages 93 inches. The draw slate varies from 8 to 18 inches with an average of 11-1/2 inches for five mines; at the sixth mine the immediate roof is a thick sandstone. Above the draw slate the usual roof coals and shales occur. The main roof at five of the mines is shale. Figure 16,A, shows some representative coal sections and immediate roof for these mines. The average cover varies from 250 to 740 feet with a maximum cover of 815 feet at one mine.

Figures 10,B, and 11,A, are representative of the general plan of development for mines of group E except that pillars are recovered by the open-end system. Table 9 gives development and operating results. In general, the pillaring lines retreat at an angle of 45°, but at one mine the retreat is at an angle of 34° with respect to the butt entries.

The general plan of development and timbering in solid places is similar to that discussed for group C of type E. The coal is developed by rooms and crosscuts into blocks varying in size from 80 to 125 feet square. Figure 22,A, shows the sequence used in mining blocks 65 by 100 feet in size. Figure 22,B, shows the sequence for blocks 88 feet square. Note that the block is first split by a 12-foot crosscut. The principle followed in all cases is to maintain a square block of coal, as the size of the block is reduced by alternate butt and face cuts. At some mines the pillar blocks are 68 feet square and these are mined by alternate butt and face cutovers. At one mine the pillar blocks are 112 feet square; on one side of the mine these blocks were mined by alternate butt and face cutovers, which made the first cutover 112 feet long, but on the other side of the mine the 112-foot blocks were first split by a crosscut, thus reducing the length of the first cutover to 48 feet. Chain pillars and barrier pillars are mined by open-end places in step with the main pillaring lines as described for group C of type E.

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 01:59 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 8.- Developmental distances and operating results for a group of 14 mines in the Fairmont district of northern West Virginia. Group D of type E

Developmental distances	Representative mines		Range for seven mines with more than 200 feet of cover			Range for seven mines with less than 200 feet of cover		
	Moderate cover (Mine 13)	Light cover (Mine 14)	Maximum	Average	Minimum	Maximum	Average	Minimum
Range of cover[1] ... feet	750–450–250	400–150–20	900	450	20	600	175	20
Width of headings ... do.	12	12	12	11.8	10	12	11.5	10
Number of headings on mains	4 to 7	6	8	5	4	6	4	2
Number of headings on faces	3 or 4	4	6	4	3	6	4	2
Heading centers on mains and faces ... feet	100	35 and 62	100	59	35	62	45	35
Heading centers on butts ... do.	100	35 and 62	100	59	35	85	50	35
Thickness of chain pillars on mains and faces ... do.	88	23 and 50	88	50	23	50	33	23
Thickness of chain pillars on butts ... do.	88	23 and 50	88	50	23	73	36	23
Distance between face entries ... do.	1,700	1,200	2,250	1,756	1,200	1,800	1,400	1,000
Center to center distances of butts ... do.	400	370 and 470	420	373	330	500	411	250
Barrier pillars on mains ... do.	125 to 200	100 to 300	250	173	100	350	184	100
Barrier pillars on faces ... do.	125 to 200	150	200	161	100	150	130	100
Width of rooms ... do.	12	18	18	12.5	10	18	15	10
Width of room pillars ... do.	88	72	88	80	68	86	71	40
Room centers ... do.	100	90	100	93	80	90	86	50
Length of rooms ... do.	300	350	350	316	300	550	354	250
Length of room necks[2] ... do.								
Width of primary pillar pocket ... do.	12	16	14	12	10	16	13	10
Width of primary pillar fender ... do.	12 or 2	7	18	8	2	8	7	6
Width of secondary pillar pocket ... do.	16 or 19	14	35	23	12	18	13	10
Width of secondary pillar fender ... do.	2	4	6	4	2	8	4	2
Angle of retreating rib line with respect to butt entries ... degrees	45	45	45	45	45	45	45	45

Operating results			Average for 14 mines
Recovery ... percent	82.4	90	83.1
Coal produced per day per man underground ... tons	6.88	5.28	6.76
Coal produced per post used ... do.	10.5	13.23	14.17
Coal produced per pound of explosive used ... do.	11.6	11.41	10.03
Fatality rate per million tons of coal produced	1.93	1.67	1.86
Frequency rate for all injuries underground	56.99	34.24	63.43
Severity rate for all injuries underground	11.13	8.42	12.18

[1] Three values represent maximum, average, and minimum values. [illegible] with narrow seams [illegible]

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 9.- Developmental distances and operating results for a group of six mines in the coking region of Pennsylvania using the open end system of pillar extraction. Group E, type E mines

Developmental distances		Representative mine, (Mine 15)	Range for six mines		
			Maximum	Average	Minimum
Range of cover[1]	feet	400-375-350	815	474	100
Width of headings	do.	10 to 12	12	11.3	10
Number of headings on mains		4	7	5	4
Number of headings on faces		4	4	3	3
Heading centers on mains	feet	30 to 50	85	64.5	50
Heading centers on faces	do.	30 to 50	100	64	50
Heading centers on butts	do.	40	125	72.5	40
Thickness of chain pillars on mains	do.	20 to 40	73	53	38
Thickness of chain pillars on faces	do.	20 to 40	88	52	38
Thickness of chain pillars on butts	do.	30	113	56	28
Distance between face entries	do.	2,000 to 5,100	3,100	1,940	1,000
Center to center distances of butts	do.	340	500	356	250
Barrier pillars on mains	do.	170 to 200	300	216	150
Barrier pillars on faces	do.	170 to 200	300	200	150
Width of rooms	do.	10 to 12	14	11.6	10
Width of room pillars	do.	100	111	84	68
Room centers	do.	112	125	96	80
Length of rooms	do.	300	400	286	200
Width of open end pillar place	do.	18	25	19.3	14
Maximum length of open end place	do.	65	112	67	38
Operating results					
Recovery	percent	85		86.7	
Coal produced per day per man underground	tons	7.4		6.64	
Coal produced per post used[2]	do.	10.2		6.77	
Coal produced per pound of explosive used	do	6.74		11.87	
Fatality rate per million tons of coal produced		0.64		2.74	
Frequency rate for all injuries underground		56.46		78.06	
Severity rate for all injuries underground		(3)		23.80	

[1]Three values represent maximum, average, and minimum values.
[2]The values represent timber for posts and crossbars only; no data are available for number of cribbing blocks used, but about 150 cribbing blocks are used per 1,000 tons of coal mined.
[3]Not available.

An excellent system of timbering is required if the open-end work is to be done safely and economically. Figure 22,C, shows the plan of timbering in an open-end place and figure 22,D, is a cross section of the open-end place giving further details of the timbering.

At one of these mines all coal is pick mined. At the other mines all coal is undercut, and at two of the mines it is center sheared in addition. No exact data are available on the percentage of machine-mined coal, but it is probably 90 to 95 percent, because all pillar coal is machine-cut except for small stumps at the end of pillar cutovers.

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

PRINCIPLES OF DEVELOPMENT AND PILLAR EXTRACTION

At some mines the details of development are planned as the coal bed and its condition becomes known, but it can be stated that a large percentage of the mines described in this report have been carefully planned by mining engineers who have considered all the factors which determine whether or not the mine shall be conducted efficiently. In deciding upon a system of development and the details to be followed, no one factor can be said to be most important; therefore, the following conditions should not be considered as of decreasing importance because of the order of their discussion.

Local customs and practices are often the basis for the choice of a particular system. This is justifiable to some extent because in any district the natural conditions for all mines are fairly similar. Therefore, the management of a new mine, knowing that nearby mines with similar conditions have used a particular system with success, follows the same system. Fairly often the opportunities for better recovery and more efficient operation are overlooked by not giving consideration to mining methods in other coal fields. Generally, the progressive mine management in any field is the one that breaks away from local customs and traditions and develops a system of mining based on all known factors, and after careful engineering planning gives the new method a fair trial under practical operating conditions.

Natural Conditions

Natural conditions must be considered. These natural conditions may be listed as depth of cover, character of immediate roof, dip of the coal bed, thickness of the coal bed, impurities in the coal bed and their location in the bed, the presence or absence of well-defined cleats in the coal, presence of gas, and probable amount of water to be handled. Frequently, mines are developed in direct opposition to the apparent dictates of these natural conditions. For instance, the dip of the coal bed apparently determines the position of the shaft or drift opening, but railroad facilities are not always available at the low point of the deposit and, further, the low point might be close to the property line and under deep cover, thus necessitating costly shaft sinking. Where facilities for river shipments are available, as along the Ohio and Monongahela Rivers, the economies of water transportation of the coal far offset the added cost of hauling against adverse grades in the mine. In some parts of Pennsylvania the coal is 7 to 9 feet thick and the top 10 to 12 inches high in sulphur. This coal is left in place to help support, with the addition of timber, the draw slate directly over it. This is a good example of leaving coal of low value in place to help increase the safety of the miner. The depth of cover is a natural factor which cannot be neglected, but it is not always the controlling factor. With increase in cover it is the general practice to increase the size of barrier and chain pillars and of room stumps and room pillars, but the converse is not true; that is, a system favorable for 400 to 500 feet of cover may be used without change for a cover of 150 to 300 feet, although it would appear that modifications would be possible for greater economy in mining. It is probable that other factors were deemed to be of greater importance and no changes were made.

The importance of cleats in the Pittsburgh coal is shown by the fact that the development of all these mines is planned so that the rooms will advance on the face cleats because the mining is easier; depending on the system used, from 65 to 100 percent of the coal is mined from places advancing on the face cleats.

Aim of Choice of Method

The choice of a method and its details should aim at (1) high recovery, (2) roof control, and (3) safety; and should provide for (4) economy by concentration, (5) proper venti-

Generated on 2024-09-18 01:58 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

lation, (6) efficient haulage, and (7) economical drainage and pumping of underground water. Any system that has been determined upon by careful engineering planning should be followed faithfully, but it should be flexible enough so that it can be altered in detail to suit the conditions as they change in the actual progress of the mining.

When the system of development has been determined upon, the next important consideration is whether or not pillars are to be recovered, and, if so, how shall they be mined. The value of the coal in place if the coal is owned by the mining company or the extraction in tons per acre required of the operator by the owner of the coal usually determines whether or not pillars are to be extracted. The necessity for protection to the owners of surface rights may also modify the problem; however, this is a legal matter and before the question of pillar extraction can be decided, the legal aspects of the relationships between the owners of the surface and the owners of the coal must be ascertained. It is generally believed that a greater percentage of lump coal results from solid work as compared to pillar work, but the strength of the coal and the method of pillar extraction also affect the percentage of lump production, as well as the method of drilling, cutting, and blasting. It cannot be said that better roof control results when pillars are not mined than when pillar recovery is attempted. Roof control depends upon the system of mining, but unless a high degree of skill in underground management is exercised the system of mining will not prevent the roof from getting out of control. Squeezes may develop as easily in mines where pillars are not extracted. It is essential, however, to use the system best adapted to the conditions. Neither can it be said that more timber is required when pillars are extracted, because the amount of timber required does not depend so much on the methods used as on the speed with which places are driven and abandoned - that is, on how much retimbering is necessary before all the coal is mined. In pillar work timbers are recovered to help roof breaks and, to a large extent, some of this timber can be used again. Recovery of timber in moderate to heavy cover is essential for roof control.

Developmental Costs

A factor of great importance insofar as costs are concerned is the amount of money that must be tied up in development work before normal production is reached. When this normal production is attained, the amount of development can be proportioned according to probable future demands. Few mining companies prepare any estimates of future demands. Such estimates, if considered only as estimates, should help guide the mine management in deciding upon the amount of development required. When demand slows up, many operators find their mines overdeveloped, which is costly; when demand picks up again, the lack of development results in a lack of ability to produce the desired amount of coal. These failures are to be attributed to lack of cooperation between the higher operating officials and the sales departments in not trying to form an estimate of the probable future demands based on the available knowledge of conditions and the past experience of these men in the coal industry.

For quick production with a minimum of development, the methods used in eastern Ohio and the Panhandle districts of Pennsylvania and West Virginia are ideal. However, if pillars are to be withdrawn, these methods are suitable only under shallow cover, and if pillars are not to be drawn, they are suitable under moderate to moderately heavy cover. From 30 to 40 percent of the coal is left in the ground to support the overburden however, and actually more development is required for a given production than is generally realized because of the large percentage of coal left in pillars.

The half-advance and half-retreat system provides for quick production, for the maintenance of a uniform daily tonnage, and for a minimum of development. The full-retreat method with short rib lines has the same qualities except that slightly more development is required

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

on account of the butt entries being fully developed before room-and-pillar work begins. Full retreat with long fracture lines requires the greatest amount of development before room-and-pillar production begins but, by maintaining an even balance between room-and-pillar work and new development, the latter need not be excessive but will be greater than with the other systems. The large number of mines using this method indicates that it has many advantages over all the other methods. These advantages, in properly managed mines, are (1) excellent roof control and (2) concentration of work. The latter includes concentration of haulage, track work, ventilation, and supervision; all these factors tend toward a lower production cost.

Size of Pillars and Stumps

In any system of development, the size of barrier pillars, chain pillars, and room stumps must be considered, and these are controlled to a large extent by the amount of cover. With the full-advance system, whether or not room pillars are extracted, the room stumps and chain pillars form a protection to the butt entry while the rooms are being worked. With a full-retreat system, these chain pillars and room stumps are mined in step with the room pillars, and in this case the chain pillars do not have to support the roof after coal has been mined out on each side of the butt entry. Some mine managers consider it good practice to drive butt entries on the same centers as rooms even though the rooms are on 100-foot centers. The chain pillars are thus developed in blocks of the same size as the room pillars and these pillar blocks are then extracted in the same order as room pillar blocks. Whether main haulage and face entry headings should be driven on 100-foot centers is questionable, but some mines follow this practice and find that when the time comes for ultimate recovery of these main entry chain pillars, the blocks are in good shape and the pillar recovery is as efficient as the recovery of room-pillar blocks.

The width of barrier pillars on main haulage roads and face entries is determined by the amount of cover, but where foresight has been used these barriers are made far wider than the amount of cover requires. In any case, the barrier pillars should be made 250 feet wide, or equal to the usual room length, to justify the expense of laying switches and track for the recovery of coal in a room 250 feet long as compared to a room only 50 or 100 feet long, as would be the case with thin barrier pillars. Some mines leave barriers as much as 500 feet wide, and some leave an entire panel unmined along the main haulage roads. This is an ultimate economy because, as the mine is worked out, large blocks of coal are available for retreat to the mine opening. Instead of being confronted with long strips of coal only 500 to 600 feet wide and cut up by four or more headings, the management has blocks of coal 1,000 feet or more in width. A long breakline can be established and a uniform system of pillar extraction can be followed as in a panel. Furthermore, a large daily production can be maintained almost to the day the mine is finally abandoned, which is economical when compared to the gradual falling off in production when only thin strips of barrier pillars remain to be mined. Whenever it is possible, the progressive mining companies mine the barrier pillars in step with the fracture line of the last panel which these barrier pillars are protecting.

The size of the panel varies even in individual mines. In many mines this variation is due to the location of property lines and the outcrop of the coal bed. In some gassy mines the panel is not made large, so that by the time the development work is completed much of the gas has been drained off before pillar work begins. For any panel, the length of the fracture line will vary depending upon the stage of completion. Thus, at the start and at the finish of the fracture line the production from the rib line will be less than normal and provision must be made to take care of this variation in production by the development of other panels. The ideal arrangement is for a new rib line to begin about the time that an old rib line is working into the corner of its panel and its production gradually diminishing.

Generated on 2024-09-18 02:04 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The essentials for good pillar work and roof control along pillaring lines are simple and consist of two things: (1) A minimum amount of development of entries and rooms ahead of the pillar line and (2) development of rooms as needed to reach the pillaring line at the proper time, and then immediate extraction of the pillar. These essentials imply a carefully planned system of development, pillar extraction, and timbering in both rooms and pillar work. It has been found that places advancing toward the gob have as good roof control as those advancing toward solid coal, and have no more, if not less, injuries from falls of roof. Opinion varies on the proper length of a rib line for its efficient supervision by the mine officials. Rib lines varying from less than 1,000 up to 4,000 feet in length have been observed. It is generally conceded that a rib line should not be any longer than can be properly supervised by one assistant mine foreman assisted by the fire bosses, rib bosses, and shot firers under his charge. About 1,500 feet would be the maximum length to suit this rule under the conditions encountered in mining the Pittsburgh coal bed.

COMPARATIVE EFFICIENCIES OF VARIOUS METHODS

In describing each type of development one or more mines were cited as representative of the system, although actually these individual mines are the best and most efficient operations of their type. These mines, all above the average in their respective fields, will be used in comparing the five types. The importance of strong financial backing necessary for efficient mine operation is shown by the fact that of these 12 mines seven are owned and controlled by strong companies in allied industries such as steel, power, and transportation, and the other five are owned by coal operating and sales companies generally considered as being financially strong.

Table 10 gives some values which offer a means of comparing the efficiencies of the various systems of mining. The values given mean little unless the conditions controlling them are understood. The factors affecting each item will be briefly discussed. In the first place, it should be evident that the methods of development and pillar extraction have little to do with the values as given in table 10. A much more important factor is the efficiency of all the details of underground operations such assupervision, haulage, cutting, blasting, timbering, and discipline.

Discussion of Operating Efficiencies

Labor Classification

Mine superintendents, mine foremen, assistant foremen, and fire bosses are all included under the classification of officials. Shot firers are not included in this class but are placed under "daymen", because although shot firers have certain supervisory duties, not all the mines employ shot firers. A high tonnage per day per official may mean that the mine workings are concentrated and that a few officials can cover the mine adequately, but on the other hand it may mean that the supervision is inadequate. In general, a low tonnage per official is characteristic of the more efficient mine, because the cost of additional supervision is more than returned in other economies which result from close management of underground operations.

Dispatchers, haulage bosses, motormen, trip riders, drivers, trap-door attendants, and bottom men are classed as haulagemen. Efficiency is therefore affected by the method of entrance to the mine, whether by shaft or by drift. Where gathering is by animals, the efficiencies will be lower and also the length of haul from the active workings to the mine opening will have its influence. However, since the majority of haulagemen are engaged in gathering and secondary haulage, the tons per day per haulageman is some indication of the degree of concentration of the mine workings.

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 02:02 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 10.- Comparative operating efficiencies of representative mines using various types of development and pillar extraction

Item	Full advance		Full re-	Half ad-	Full retreat with long pillaring lines						
	Without pillar recovery	With pillar recovery	treat with short pillar lines	vance and half retreat	Room centers less than 50 feet	Room centers more than 50 feet	Pillar blocks in Connellsville region		Pillar blocks in Fairmont region		Open-end pillar extraction
Type[1]	A	B	C	D	E-A	E-B	E-C	E-C	E-D	E-D	E-E
Mine number	1	2	3	5	7	9	10	11	12	13	14	15
Coal produced per day, tons:												
Per mine official	401	394	259	231	187	190	309	216	431	208	(2)	(2)
Per haulageman	63	77	65	100	57	59	95	46	108	78	(2)	(2)
Per machineman	71	112	60	196	99	72	412	169	185	130	(2)	(2)
Per miner	7.3	10.1	5.6	10.7	6.5	6.8	11.1	10.7	10.9	10.3	11.6	(2)
Per dayman	55	102	92	43	47	82	57	20	31	32	(2)	(2)
Per man underground	5.3	7.5	4.4	7.4	4.8	5.1	8.1	5.7	7.1	6.5	5.8	7.4
Active areas of exposure, square feet:												
Per ton of daily production	500	700	700	500	400	300	800	(2)	300	200	3,800	300
Per man underground	3,400	4,900	3,300	3,700	1,800	1,700	5,100	(2)	2,000	2,300	25,800	2,800
Production, tons:												
Per pound of explosive used	(2)	(2)	6.8	(2)	11.3	(2)	(2)	6.1	7.7	(2)	11.4	(2)
Per post used	[3]4.7	4.0	4.8	5.2	4.8	4.7	9.6	6.7	3.7	10.5	13.2	[3]3.0
Recovery of coal, percent	62.3	[3]65	[3]80	85	86	(2)	(2)	87	75	(2)	(2)	(2)
Accident rates:												
Fatalities per million tons	0.91	3.60	2.38	1.86	4.15	0	2.94	1.41	0.54	1.93	1.23	0.64
Frequency rate	179.7	26.0	123.0	60.4	196.6	27.7	252.2	67.7	64.7	57.0	34.2	56.5
Severity rate	9.2	25.9	13.6	10.8	21.4	0.2	21.0	7.4	6.1	11.1	8.4	(2)
Cost of compensation, cents per ton	3.8	3.0	4.4	1.1	3.6	(2)	(2)	1.3	1.1	2.4	2.4	(2)
Accident rates, average for each type:												
Fatalities per million tons	4.1		0.6	1.8	4.0	1.7	2.0	2.8		1.9		[4]2.7 [5]2.1
Frequency rate	126.0		157.3	80.8	142.0	128.7	101.9	113.8		63.4		[4]78.1 [5]62.0
Severity rate	21.9		9.2	10.4	18.8	9.1	15.3	15.9		12.2		[4]23.8 [6]14.5

1. As classified in this report. 2. Information not available. 3. Estimated. 4. For six mines. 5. For five mines. 6. For four mines.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Machinemen and their assistants are included under the classification of machinemen. Here again the tons per man is a measure of degree of concentration of work, because the shorter the moves from face to face the greater the tonnage of coal cut per shift. But many factors influence these values, such as the height of coal, whether track-mounted or short-wall machines are used, the amount of pick coal mined, whether the coal is bottom cut, top cut, or sheared, whether the machinemen also drill the shot holes, whether the coal is cut on the night shift, and whether the clean-up system used allows the loaders to load out a full cut daily or permits the miners to load coal at their own convenience, thus slowing up the tonnage per mining machine.

The tonnage per day per miner is a measure of the efficiency of that class of labor and also the skill of management in proper organization of the mine to serve the face worker. Factors affecting these values are as follows;- character of car supply, amount of slate to be handled, whether miners or machinemen drill the shot holes, the amount of timbering done by the miners, and the percentage of pick mined coal. At some mines the duties of the miners consist only of loading coal and setting the necessary timbers to protect themselves at the face. At other mines the loaders have to load coal, set timber, handle draw slate, drill holes, and lay track. Obviously, with such variation in the duties of a loader, tonnage per shift will vary, regardless of the methods of development and pillar extraction.

Under the classification of daymen are included timbermen, trackmen, pipemen and pumpmen, bratticemen, masons, and laborers. Here again tonnages per shift should be high if the work is concentrated, but a high tonnage may indicate that the proper maintenance of the mine is being neglected to reduce the immediate costs and, conversely, a low tonnage per shift may mean that the daymen are not properly supervised or that not enough men are being employed to maintain the mine in first-class condition. Natural conditions, such as character of roof and amount of water to be handled, particularly in working places, affects these results, although in respect to water, the efficient mines alter the regular method of development so that there will be a natural gravity drainage away from all working places.

The tonnage per day per man underground is a true measure of the efficiency of operation, including development, pillar extraction, haulage, supervision and safety. The values given in table 10 are based on single calendar years which were chosen to represent, as nearly as possible from the data available, years of about equal business activity for all the mines. Efficiencies may vary from year to year for individual mines; this was particularly true in 1929 and 1932. During the latter year much effort was made to distribute the small amount of work among as many men as possible, and under such circumstances there was a tendency toward reduction in tons per man underground. The general practice is to work one man in each solid place and two men in pillar places. This is varied according to the necessary speed of development or pillar extraction required to maintain uniform rib lines. As many as four to eight men may be worked on a pillar stump if its removal is urgently necessary.

Areas of Exposure

The areas of exposure listed in table 10 indicate the amount of exposed roof area to be maintained on the basis of the number of men underground and the average daily production. These values indicate that, in general, the mines extracting pillars have less unit area of exposure, but to a large extent this is a result of more efficient underground management. Areas of exposure are a poor indication of the efficiency of a method of development. A mine producing a maximum possible tonnage will have a minimum area of exposure, but if the production is curtailed, the unit areas will increase, and then it would appear that the system is not adaptable. As a mine grows older, the length of haulage roads increases, which adds considerably to the area of exposure. Efficient underground management can reduce areas of

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

exposure, regardless of the method of development. In eastern Ohio rooms are 24 feet wide, and with coal 5 feet high and a 6-foot undercut, each room should produce about 29 tons per shift. Therefore, when only one man works in each place with an average daily production of 8.7 tons, at least 230 places are necessary for the mine to produce 2,000 tons daily. In mines extracting pillars the daily production per loader ranges from 5.6 to 11.6 tons, and the average for nine of these mines, as given in table 10, is 9.4 tons. In these mines, assuming a place 12 feet wide, coal 6 feet high, and a 6-foot cut, each place should produce about 18 tons per shift. In normal times it is the practice at these mines to work two men in each place and load out a cut of coal at each face every day the mine works. Therefore, to produce 2,000 tons per day, only about 111 places are required to mine this production. These comparative values indicate that the kind of underground management is equal in importance to the methods of development, if the areas of exposure are to be kept at a minimum.

Explosives and Timber

The tons of coal produced per pound of explosive used may depend upon the amount of pillar work, but greater variation is caused by the kind of explosive used, the strength of the coal, whether or not the coal is undercut and sheared, the amount of pick work, and the demand for lump coal. Permissible explosives are generally used in these mines whether gassy or not, but in some mines black powder in pellet form is used.

The amount of coal produced per post used is higher in general when pillars are extracted than when pillars are not extracted. The character of roof is a factor which largely determines the amount of timber needed, but if two mines having similar roof conditions are compared, the amount of timber used will not depend so much on the method of development and pillar extraction as on the speed with which rooms are driven and pillars extracted. When working places remain idle, retimbering becomes necessary and thus the use of timber is greatly increased.

Coal Extracted

The data given on the percentage of coal recovered is not comparable in all cases. Some of the information is taken from estimates made by company engineers based on surveys, and some is merely the guess of mine officials. In table 10 the percentages of recovery as given for mines 1, 3, 5, 11, and 12 are engineering estimates. For the methods used in Ohio and the Panhandle district of West Virginia the recovery will range from 55 to 70 percent, and for mines recovering pillars from 75 to 95 percent. An important factor in high recovery is steady mine operation. Much coal is lost in pillar stumps when mines operate only one or two days a week.

Accidents

The data given in table 10 with respect to underground injuries indicate that the recovery of coal in pillars can be done safely. The problem of safe mining does not depend so much upon whether or not pillars are extracted but rather on the efforts of the management toward the enforcement of safe practices by all underground workers. In table 10 the accident rates are given for the 12 selected mines and also the average rates for each type. The rates for group E of type E are high because of the great number of injuries and fatalities at one of the six mines. It should be noted that mines recovering pillars have a lower fatality rate than those not recovering pillars, and in general the same holds true for the frequency and severity of all underground injuries.

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Types C and E have these low rates because the method of development and pillar extractions requires close supervision, and it naturally follows that the safety of the worker at the face is also closely supervised. As laxity in management of development and pillar extraction cannot be tolerated with these types, it therefore follows that laxity in other details of underground mining, particularly with respect to safety, is not tolerated. A method of development requiring close supervision apparently induces the close supervision necessary to reduce injuries.

CONCLUSIONS

From the foregoing discussion it is evident that for an efficient mine the first essential consideration is the selection of a system of development and pillar extraction suitable to the natural conditions encountered; and the second essential consideration, of equal if not greater importance, is the efficient management of all the details of underground operations. Of the five types of development discussed in this paper, the degree of management necessary to control development increases from type A to type E. It is very probable that mines of type E are more efficient than those of other types for the simple reason that the method of mining must be closely supervised, and it is natural to expect that this keener supervision of development will also result in keener supervision of all the other details of mining. With type E it is essential that all mining operations proceed on a uniform schedule to maintain uniform pillaring lines. In types A and B uniform mining is not so essential; it can be neglected to some extent, and with it other details of mining are likely to be neglected by the management.

This discussion has dealt with engineering problems relating to the development of plans of mining which have different degrees of efficiency in operation and the recovery of coal, has brought to the attention the loss of valuable areas of coal that might be recovered by the adoption of methods which have proved successful in other fields having similar natural conditions, and points out general types of mining plans that have established high recovery ratios with a minimum of mine development and with relatively low accident rates.

Generated on 2024-09-18 02:01 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-18 02:00 GMT / https://hdl.handle.net/2027/osu.32435030644066
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

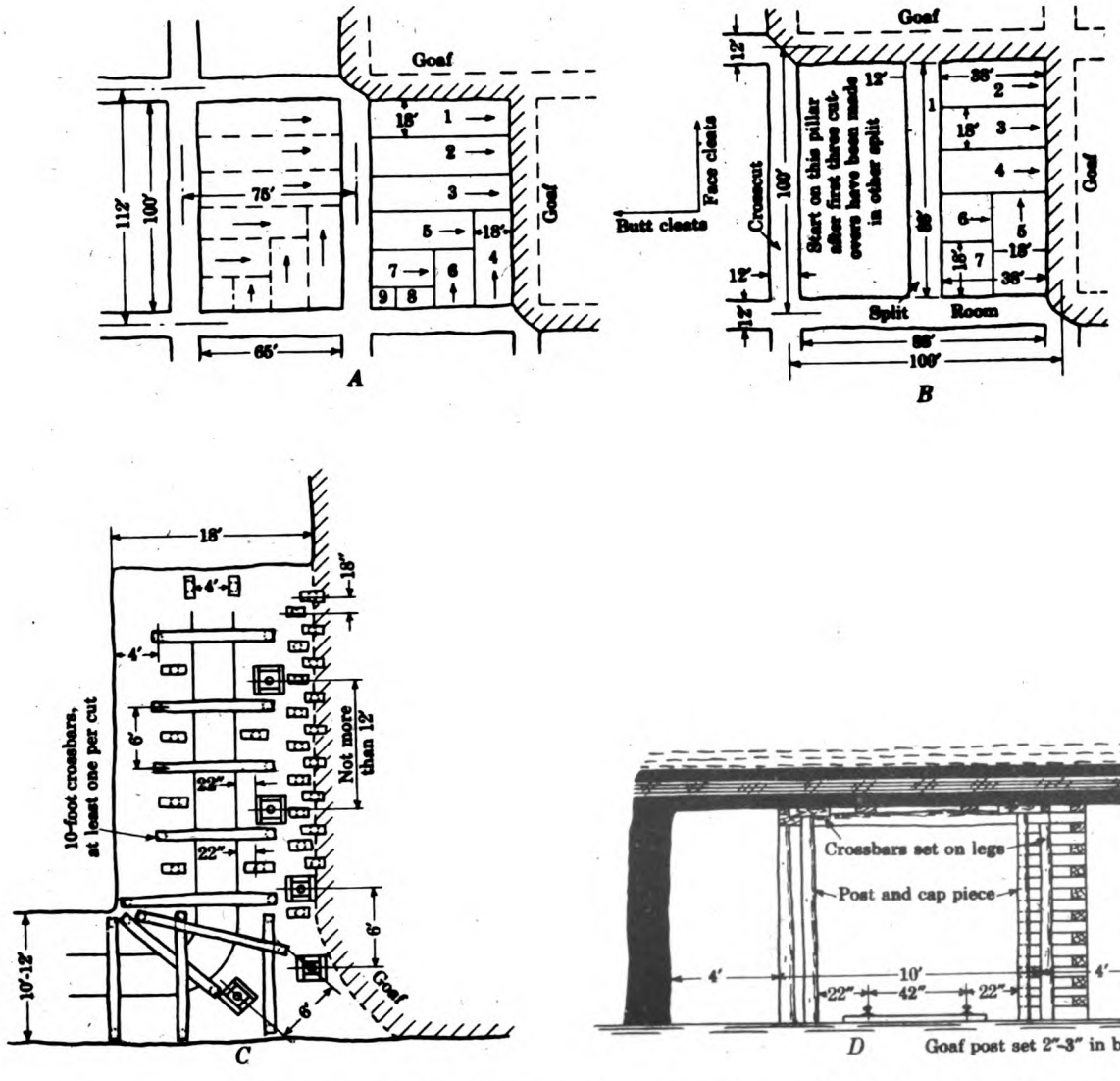

Figure 22.- Sequence of open-end pillar mining and timbering methods as practiced by mines in the coking region of Pennsylvania, group E, type E mines: A, Sequence of extraction of blocks 65 by 100 feet; B, sequence of extraction for blocks 88 feet square; C, plan of timbering in open-end places; D, section across open end showing timbering details.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY